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SBIR Phase II Final Report: Casualty Handling Simulation Using the Scenario-based Engineering Process

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ScenPro, Inc.

Abstract

This document is the Final Report for SBIR # N00014-97-C-0317. This Small Business Innovation Research project was funded by the Office of Naval Research. The effort started on 4 April 1997 and concluded on 28 February 2000. The title of the contract is Casualty Handling Simulation Using the Scenario-based Engineering Process. The goal of the effort was to create a computer-based simulation capable of simulating the flow of casualties through a medical treatment facility. In particular, the effort was focused on the medical space being designed for the LPD-17.

During this effort, ScenPro, Inc. developed a Casualty Flow Analysis Tool, CasFlow. CasFlow combines a discrete event simulator with MS Visio™, MS Access™, and MS Excel™ to enable medical planners to evaluate resource needs using user-specified scenarios. CasFlow "moves" casualties through a Medical Treatment Facility (MTF) and tracks a wide variety of statistical information related to mortality, delays, staff use, and consumption of resources.

The movement profiles and resource consumption rates are based on treatment database protocols and materiel use databases developed by the DMSB/JRCAB. CasFlow accepts or creates a casualty stream and tracks treatment times, delays, resource consumption (beds, staff, Class VIII supplies, and evacuation requirements), and casualty movement within the medical system. As different casualty sets are entered into the system, the tool highlights system bottlenecks produced by resource shortfalls. Problems areas are easily visualized using PivotTables and graphical representations produced by CasFlow.

This document has been prepared in accordance with format requirements in ANSI Z39.18, Scientific and Technical Reports: Organization, Preparation and Production.

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1.0 Summary

The original intent of this SBIR was use simulation technology and the Scenario-based Engineering Process to help the US Navy determine the proper configuration for the medical space of the new LPD-17. In order to achieve this goal, ScenPro developed a discrete-event simulation, CasFlow, capable of simulating the movement of casualties through a medical treatment facility. Data was slowly collected from a variety of sources to "power" the simulation. This data includes casualty streams, medical treatment facility configurations, and treatment protocols.

The resulting system accepts a casualty stream and moves the casualties, in the appropriate treatment plan through a medical treatment facility. As the casualties move, they utilize and consume resources such as beds, staff, supplies, equipment, and transportation. The user can select different algorithms to deal with resource contention. All resource usage and consumption is recorded. A post-simulation analysis tool reads this usage and consumption data and presents the user with a variety of metrics showing how the configuration of the medical treatment facility impacted the mortality and return to duty times of the casualties.

Tests were run on realistic casualty streams for the proposed LPD-17 medical space. The tests show that the current plan meets the various requirements for casualty throughput and survivability.

2.0 Introduction

Effective shipboard medical care depends on having the proper resource mix for casualties as they flow through the system. Identifying the proper mix is complicated by many factors, including the specific casualty stream, the criteria for selecting between the different casualties waiting for treatment, and the specific configuration of the medical treatment facility.

To address this problem ScenPro, Inc. developed a Casualty Flow Analysis Tool, CasFlow, under funding from the Office of Naval Research, contract number N00014-97-C-0317. CasFlow combines a discrete event simulator with MS Visio™, MS Access™, and MS Excel™ to enable medical planners to evaluate resource needs using user-specified scenarios. CasFlow "moves" casualties through a Medical Treatment Facility (MTF) and tracks a wide variety of statistical information related to mortality, delays, staff use, and consumption of resources.

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3.0 Methods, Assumptions, and Procedures

A variety of technical hurdles had to be overcome during the development of CasFlow. The majority of these had to do with collecting and verifying the data necessary to operate the simulation engine. This section reviews these technical hurdles and the steps ScenPro took toward overcoming them.

An early challenge was to determine the exact configuration of the software tool to insure maximum utility without going too far beyond the original scope of the contract. The original use of the system was to simulate casualty flow through the medical treatment facility within the LPD-17 to identify bottlenecks. Because the LPD-17 medical space was still under development, it was determined that this tool might be able to predict treatment areas that had insufficient resources to handle expected casualty streams.

In order to identify bottlenecks within an MTF, their causes had to be identified. Early knowledge acquisition sessions with subject matter experts identified the following resources as those that could create bottlenecks: beds, staff, equipment, supplies, and transports. Further, it was determined that in order for a bottleneck to have true significance, it was important to use actual mortality data to cause casualties that were delayed too long to "die of wounds."

Finally, the details of the medical treatment for each casualty had to be captured. To be able to accurately simulate treatment, it was necessary to have data about beds, staff, equipment, supplies, and the details of transport.

Simulation Engine

Of all the technical challenges of the CasFlow project, the simulation engine was one of the most straightforward. The key issue was what type of simulation to specify. Early research showed that a discrete event simulation would be best... since the nature of the task-time-treater files was to specify tasks as blocks of time. Using a discrete event simulation would mean that the "Current time" could jump across blocks of time and result in a faster system.

Since the first simulation engine was written in 1997 in Visual Basic, it has been converted into the C++ programming language and then turned into a .DLL – a type of library of functions for other programs to use. Each of these changes was to support greater functionality or faster throughput.

Since its original development, the simulation engine has had two key features added to it, the first is the inclusion of mortality data to cause casualties to die if they do not receive treatment quickly enough. The second feature created work schedules for staff – to insure that no employee was overworked.

A recent change in the simulation engine was to convert from using text-based ".ini" files to store MTF configuration and scenario data. These data are now being stored in tables in database.

Another modification underway is changing the way that data are moved from the simulation to the Excel-based analysis system. The original technique was for the simulation to store the data in two text-based files (roomstat.csv and caslog.tex). Once the simulation completed, the Excel analysis tool would read these files, modify the structure of the data, and write the data out into an Access database. The new technique is for the simulation engine to write the data directly in the modified format into the Access database – greatly speeding the post processing.

Casualty Streams

An important part of a casualty flow simulation is a casualty stream. Each military conflict has a different casualty stream based upon the ability of the enemy, the geographic location (including terrain), the weather, duration, number of troops deployed, and other factors. It has been difficult to obtain realistic casualty streams for the LPD-17. There are a number of reasons for this, but the most important is that there has never been a ship exactly like the LPD-17 deployed before – making it difficult to determine exactly which "historical" casualty stream to use.

ScenPro approached this problem in four different ways. Three of these efforts yielded results. The first approach was to get permission to use output from an Army-based casualty generator. Paula Konoske at NHRC had access to this casualty stream generator and we had high hopes to get casualty data from it. In the end, we were never able to get these data due to security concerns.

Our second approach was to work with Chris Blood of NHRC. Mr. Blood has performed research studying the statistical distributions of casualties over a number of different military conflicts[1,2]. Because we couldn't get casualty stream data directly from Mr. Blood, we designed and developed a small computer program module that used Mr. Blood's statistics to generate a casualty stream. This program is currently a part of the CasFlow Wizard. The inputs to the module are number of troops, number of days, and a flag deciding if DNBI's are to be included. The output of the module is a casualty stream in the necessary CasFlow format.

Our third approach to developing a casualty stream was to hand write it. To do this we employed the full power of the Scenario Generation portion of the Scenario-based Engineering Process. After initial research, we were directed to LtC Sally Veasey – an expert Navy planner. In discussions with LtC Veasey we created a scenario based around a Chemical gas attack near the U.S. Embassy in Tunis, Tunisia. This attack resulted in a

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[1] Blood, C. G., Nirona, C. B., Pederson, L. S., Medical Resource Planning: The Need to Use a Standardized Diagnostic System, Report Number 89-41, Naval Health Research Center, San Diego, CA, 1989.
[2] Blood, C. G., Nirona, C. B., Outpatient Illness Incident Aboard U. S. Navy Ships During and Following the Vietnam Conflict, Report Number 89-15, Naval Health Research Center, San Diego, CA, 1989.

Non-combatant Evacuation Operation by an LPD-17. The NEO used the helicopters associated with the LPD-17 and was able to get all of the casualties evacuated to the LPD-17 within 11 hours. As is appropriate for helicopter evacuation, the casualties arrived at the ship in batches. The resulting handcrafted casualty stream follows the expected casualty arrival rate. Similarly casualty streams were developed for a mine clearing operation in Guantanamo Bay, Cuba.

Our fourth approach was to take an actual casualty stream and to use a medical regulator to "distribute" the casualties among a number of MTFs – including one or more LPD-17s. This was done with the casualties associated with the Mogadishu, Somalia raid.

To generate the casualty stream, ScenPro employees studied several literature sources about the Mogadishu raid, such as "Blackhawk Down." From these, a list was created describing each of the 79 U.S. casualties. For each casualty, their time of arrival at a medical treatment facility and their injuries were recorded.

In order to apply this data properly to the LPD-17, a scenario was created that included two LPD-17s. A medical regulator was given the task of allocating the casualties, as they were actually received in Mogadishu, across the expanded set of medical treatment facilities. The casualties that were sent to the LPD-17s were simulated. It was determined that no LPD-17 casualty had any adverse affects from bottlenecks. This casualty stream was used in the final test of the system for the DMPILS-99 conference.

LPD-17 Configuration

Early in the development of CasFlow it became important to identify the "approximate" configuration of the LPD-17. Once an approximate configuration was found, small changes to that configuration could be simulated and contrasted to identify the configuration with the minimum bottlenecks.

ScenPro was able to get an early floorplan of the medical space of the LPD-17 (Figure 3-1) and used this configuration for many months. Much later, a more accurate design was identified and used for the remainder of the development.

The final, more accurate design included:

- 9 Triage Beds
- 5 Pre-OP Room
- 1 Operating Room
- 1 Room that could be converted to an Operating Room in 4 hours
- 7 ICU Beds
- 17 Ward Beds
- 2 Medical Consultation Rooms (Exam Rooms)
- 2 Dental Operating Rooms
- Blood Refrigerators
- X-ray
- Laboratory

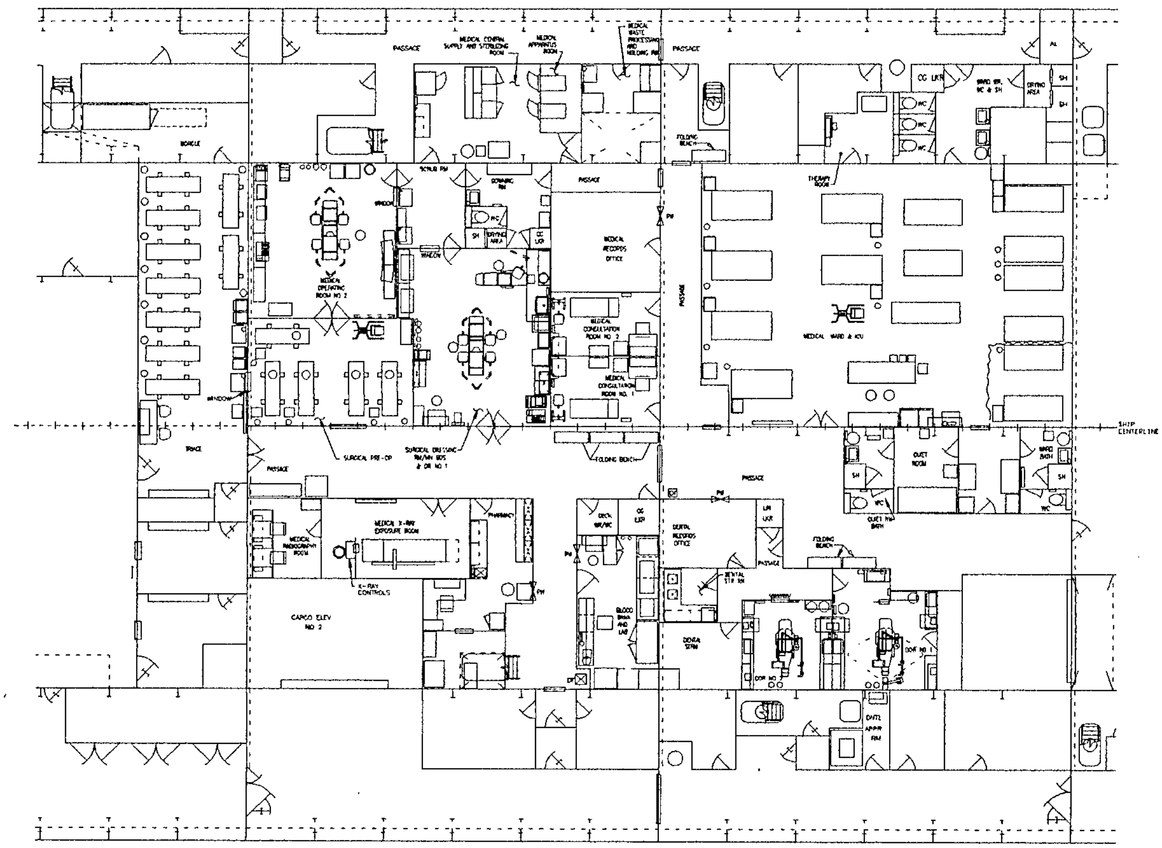


Figure 3-1 LPD-17 Medical Treatment Facility

LPD-17 Staffing

Our initial attempt to gather detailed information about the proposed medical staff of the LPD-17 led us to Dennis Moses. We held a knowledge acquisition session with Mr. Moses during which time he hypothesized about the medical staff.

This original medical staff consisted of:

- 1 General Medical officer
- 1 Independent Duty Corpsman (8425)
- 1 Lab Tech (8506)
- 1 OR Tech (8483)
- 1 Pharmacy Tech (8482)
- 1 X-Ray Tech (8452)
- 1 Orthopedic Tech (8489)
- 1 Medical Repair Tech (8478)

- 4 Corpsmen (0000)

And the medical augmentation was

- 2 General Surgeon
- 2 Orthopedic Surgeon
- 2 Anesthetist / Nurse Anesthetist
- 2 OR Nurse
- 2 ICU Nurse
- 2 Staff Nurse
- 2 OR Tech (8483)
- 2 Respiratory Tech
- 1 Orthopedic Tech (8489)
- 2 Lab Tech (one 8501 and one 8506)
- 1 MSC Officer (admin officer 0800)
- 12 Corpsmen (0000)

At the DMPILS-99 conference, CAPT John Fahey was identified as the person who might know the most recent proposed staffing for the LPD-17. ScenPro employees attempted to contact CAPT Fahey on several occasions, but none of our calls were ever returned.

More recently, attempts were made to get lists of allocated staffing for all Naval Medical Treatment Facilities. This was done through the Navy Manpower Analysis Center. Our contact at this facility is HMCS Robert Ray. He was extremely helpful and provided staffing numbers for many classes of ships.

In August 1999, at the Common User Database Requirements Meeting, Mr. Gately learned about the Combat Medical Support Qualifications Inventory (CMSQI) database. This is a database describing the skills of each different medical practitioner in the Army, Navy, and Air Force. A request to Bill Pugh provided the CasFlow team with these data. While the current version of CasFlow does not use these data, the data have been analyzed and their use in the form of substitution tables has been determined. Future versions of CasFlow will prove more robust based upon these data.

LPD-17 Equipment and Supplies

Research was done to identify the equipment and supplies expected to be on the LPD-17. Our first approach to this was to speak with Buck Buchannan. He provided us with a key insight – that until the LPD-17's AMALs assignments were actually completed, we should use the LPD's (Austin class ship) AMAL.

Later we spoke with Joe Deane who helped us understand the details of the AMAL files.

Mr. Deane also said that we should be using the LPH's AMAL instead of the older (and smaller) LPD. His final analysis was to use:

- **CORE**

- 800 - surface ship core

- **SUPPLEMENTARY**
  - 802 – proposed AMAL
  - 803 – audio
  - 806 – surgical
  - 906 – x-ray
  - 915 – lab
  - 918 – proposed AMAL
  - 919 – Fly Away Kit
  - 925 - Basic Antidote Locker
  - 927 - first aid kit
  - 937 - BMET Afloat
  - 944 - Individual HM Emergency Response Kit (HM = Hospital Corpsman)
  - 955 - Battle Dressing Stations
  - 964 - Portable Medical Locker

We were able to get files that described the contents of the AMALs and enter these into our database.

In September, we acquired a six-month subscription to the Universal Data Repository (UDR) Medical Catalog. This catalog of data contained an updated version of the list of AMALs assigned to the different classes of ships. We used the November 1999 edition to update our database for the LPD-17.

LPD-17 Transports

At the DMPILS-99 conference we learned that the LPD-17 would support 2 CH-46 helicopters and 2 LCAC. The capacity of these transports is:

CH-46 Sea Knight Helicopter
- Littered 15
- Ambulatory 22
- Split Littered 6
- Split Ambulatory 15

LCAC – Landing Craft Air Cushioned
- Littered 3
- Ambulatory 12
- Split Littered 1
- Split Ambulatory 6

Mortality

In order to produce realistic results, it was important for CasFlow to have clinical outcomes similar to the real world. This was particularly true for casualties that died of wounds while undergoing medical treatment. To support this feature, ScenPro investigated the availability of mortality data.

ScenPro identified the UHSUS Mortality data, acquired the data, and incorporated the data in the simulation engine and the TTT database. The mortality data were originally gathered by the Casualty Care Research Center (CCRC) of the Uniformed Services University of the Health Sciences (USUHS) and the Trauma Research Group (TRG) of the Washington Hospital Center (WHC), which directed the Major Trauma Outcome Study (MTOS) for the American College of Surgeons. This group was engaged to work with the patient treatment calculus panel of the War Time Planning System Office (WAR-MED) Steering Committee and BDM International to develop a methodology for using MTOS data to support WAR-MED project needs.

The data in the USUHS study included:

- 127,000 records
- Males, 18-45 years of age
  - Correspond to 190 injury PCs
  - Data collected with ICD-9-CM classifications (800-959) and AIS
  - 85 severity and region scores (2 digits, each 1-6)
  - Sorted into 29 patient groups
  - Similar with respect to anatomic region, mortality, and length of stay in hospital and ICU
  - Each ICD and AIS pair associated with a unique group
  - PCs mapped to ICD/AIS pairs and then to groups

The CasFlow simulation engine was modified to utilize these data. The process is shown in Figure 3-2 and described below:

- For each casualty, upon arrival at an MTF, generate a random number 0.0 → 1.0).
- Compare this number against the summary number for their injury indicating if this casualty will be on a "death path".
- If the casualty is not on a death path, then the casualty will not die, regardless of their delays.
- If the casualty does get selected for the death path, generate a second random number (0.0 → 1.0).
- This second random number is interpolated against a set of numbers to compute a time indicating when this casualty will die.
- If the casualty is still in the medical treatment facility at the interpolated time, then the casualty dies.

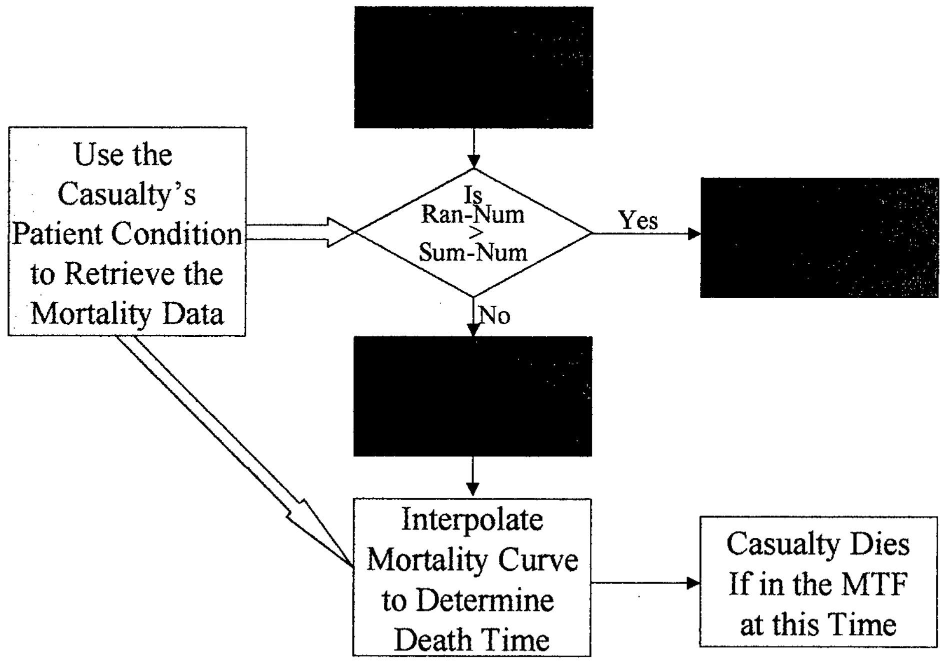


Figure 3-2 Mortality Curve Flow Chart

When a casualty dies, the resources they have already consumed are accounted for, but no additional resources are used. In the CasFlow Analysis tool, the "died of wounds" are highlighted.

Task-Time-Treater Files

The key data necessary to perform casualty flow simulations are the treatment protocols for the various injuries. These protocols describe step-by-step the treatment performed on a casualty from admission to discharge. For each task in the protocol, the information necessary for the simulation is:

Name/Description	Preferable
Location	Mandatory
Time	Mandatory
Staff	Mandatory
Equipment	Preferable
Supplies	Mandatory
Patient Present	Optional
Parallel Task	Optional

Our first attempt at getting detailed TTT data was from Paula Konoske of NHRC. For a variety of reasons, we were unable to obtain any data from her. We contacted a number of other organizations and eventually received several Treatment Briefs. From these treatment briefs, ScenPro employees created a TTT database for use during system development.

Data was eventually acquired from the Defense Medical Standardization Board. They supplied to us a file called "TTM for export.mdb." This data file included treatment protocols for 300 patient conditions. Among the TTM data were:

Name/Description
Location (as Functional Area)
Time (of Materiel/Equipment use)
Supplies

This data lacked specific items required for the simulation, so ScenPro identified a subject matter expert who added the following fields to the data

Staff
Location (as Bed)
Patient Time

Much later, in December 1999, we received the latest release of the DMSB (now called JRCAB) data. This data is contained in a file called "TTT DatabaseV1.1.mdb." While this database did have more information, it still did not have staff, bed location, or patient time.

In December 1999 and January 2000, ScenPro integrated the Staff, Bed, and Patient Time fields from the old database into the new JRCAB database.

There continue to be many problems with the TTT database. Among these are

- Limited number of patient conditions
- Limited availability of patient conditions at all Levels of Care
- Questionable linking with ICD-9 codes
- Integrated Mortality
- Optional paths – or expanded patient conditions
- Inclusion of complete Staff resource needs
- Staff substitution guidelines
- Inclusion of complete Equipment needs
- Inclusion of complete Material needs including blood and oxygen
- Details of patient disposition
- Indicate when patient is not present for treatment step (i.e. Lab Work)
- Indicate treatment steps that can be skipped during high op tempo
- Patient movement items

4.0 Results and Discussion

CasFlow integrates a robust simulation engine with several COTS tools – providing the necessary speed and the powerful GUI's available in MS Visio, MS Access, and MS Excel. Figure 4-1 shows the top level CasFlow COTS architecture. Visio (a business graphics software package) is used to input MTF configurations, casualty streams, and scenarios. MS Access is used to store the Task-Time-Treater Treatment Protocol information and intermediate results. MS Excel is used to produce the PivotTables and charts necessary for complete analysis.

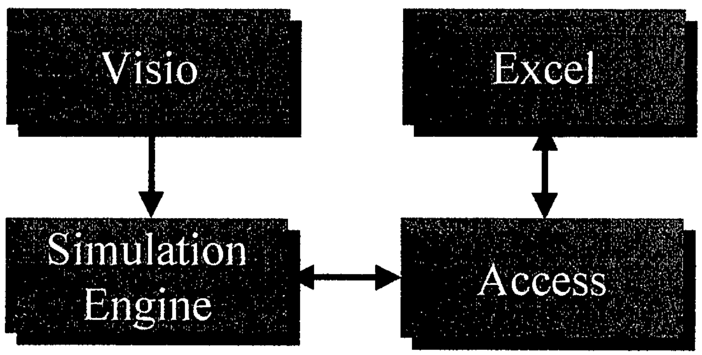


Figure 4-1 CasFlow Top Level COTS Architecture

System Overview

The operation of CasFlow is summarized in Figure 4-2:

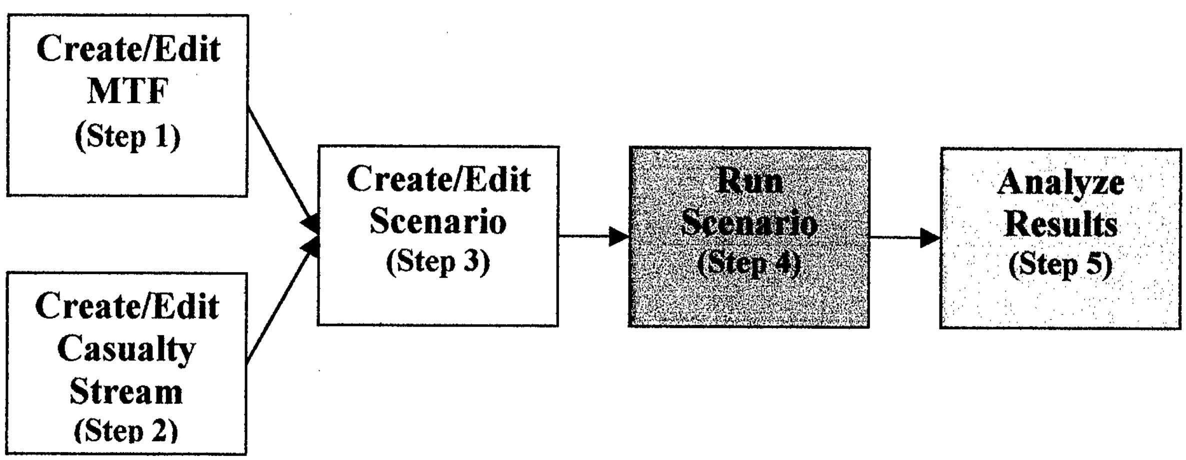


Figure 4-2 CasFlow User Flow Chart

- Step 1 involves either creating a new MTF or modifying an existing MTF (via the User Interface);
- Step 2 involves either creating a new casualty stream or editing an existing one (via the User Interface);

- Step 3 involves either creating a new scenario or editing an existing one (via the User Interface);
- Step 4 involves running the scenario through the Simulation Engine.
- Step 5 involves analyzing the results (via the CasFlow Analysis Tool) and making adjustments accordingly.

CasFlow Architecture

The CasFlow architecture is comprised of the following four functions: the User Interface, the Databases, the Simulation Engine, and the CasFlow Analysis Tool as shown in Figure 4-3.

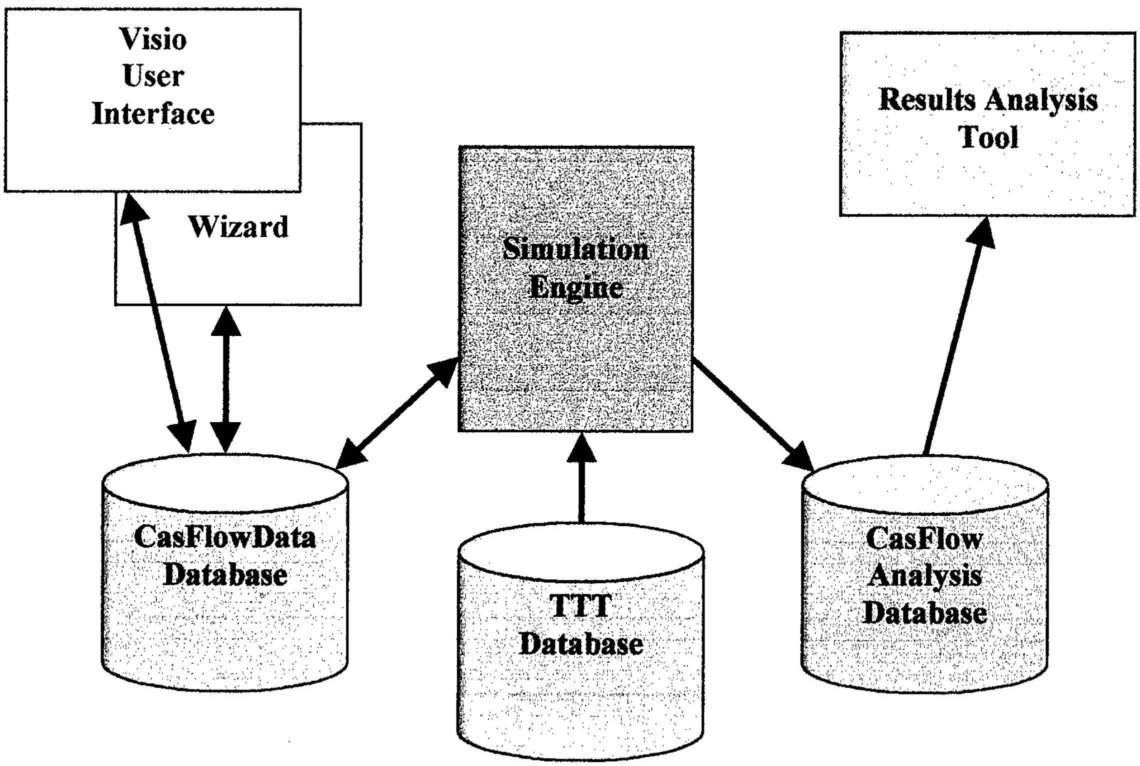


Figure 4-3 CasFlow Architecture

User Interface

Two user interfaces have been incorporated into CasFlow: a graphical user interface (GUI) using Visio and a wizard-type interface with dialog boxes.

GUI with Visio

The initial screen of the Visio-based graphical interface tool is shown in Figure 4-4. From this screen, the user can create a new MTF Configuration or edit a previously defined MTF; create a new casualty stream or edit a previously defined casualty stream; create a new scenario or edit a previously defined scenario; or run a scenario.

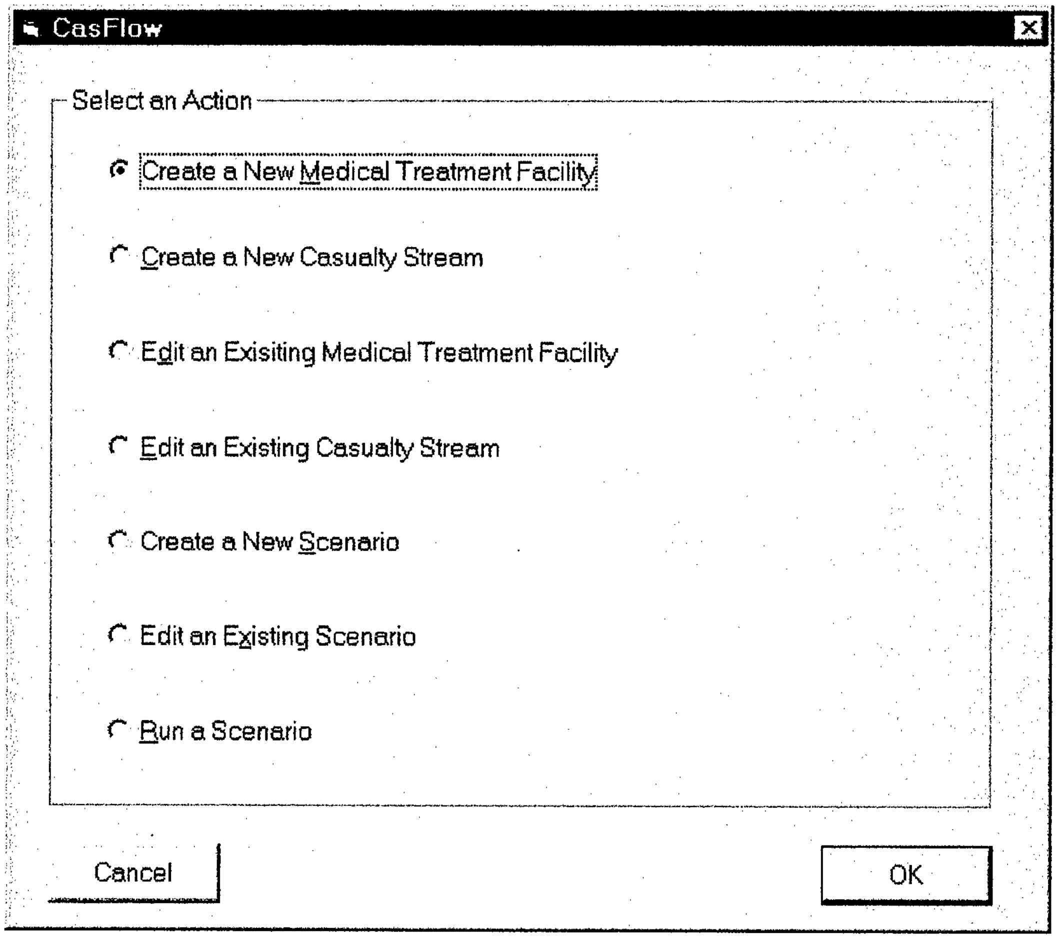


Figure 4-4 CasFlow Top-Level Dialog Box

The MTF configuration screens utilize the drag and drop features of Visio as shown in the Figure 4-5. The components that make up an MTF are identified with the use of Visio stencils. The user selects the component, such as Pre-Op beds, and drags it to the "Bed" location on the adjacent box. A dialog box appears asking for the number of Pre-Op beds located within the MTF. The same procedure is used to configure the MTF for the available staff, supplies, equipment, and transports.

The CasFlow User's Manual, located in the Appendix, describes the procedures for using the Graphical User Interface in detail.

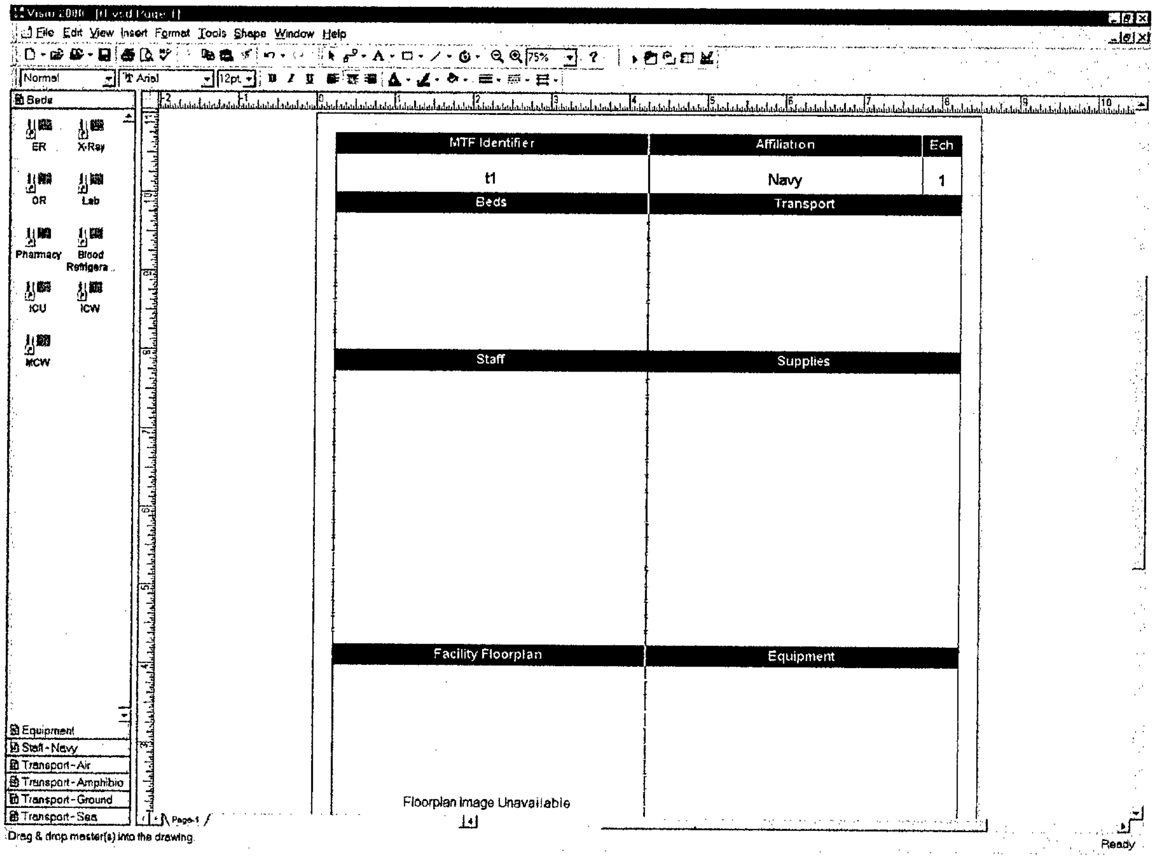


Figure 4-5 MTF Configuration Drag and Drop Display

Another step in the running of a scenario simulation in CasFlow is to create or edit a casualty stream. The casualty stream defines the injuries that occur during the scenario. Figure 4-6 is an example of a casualty stream created with the graphical user interface. The user selects the "Casualties" icon and drags it to the adjacent box to place it on the timeline at the time when the casualty presents to the medical treatment facility. In this example, the casualty presents during the early part of the first day of the scenario. A dialog box, shown in Figure 4-7, appears and the user is required to indicate the number of casualties, indicate the patient condition code, and indicate if disease or a non-battle injury caused the injury. The patient condition codes are described in greater detail in the Database section of this document.

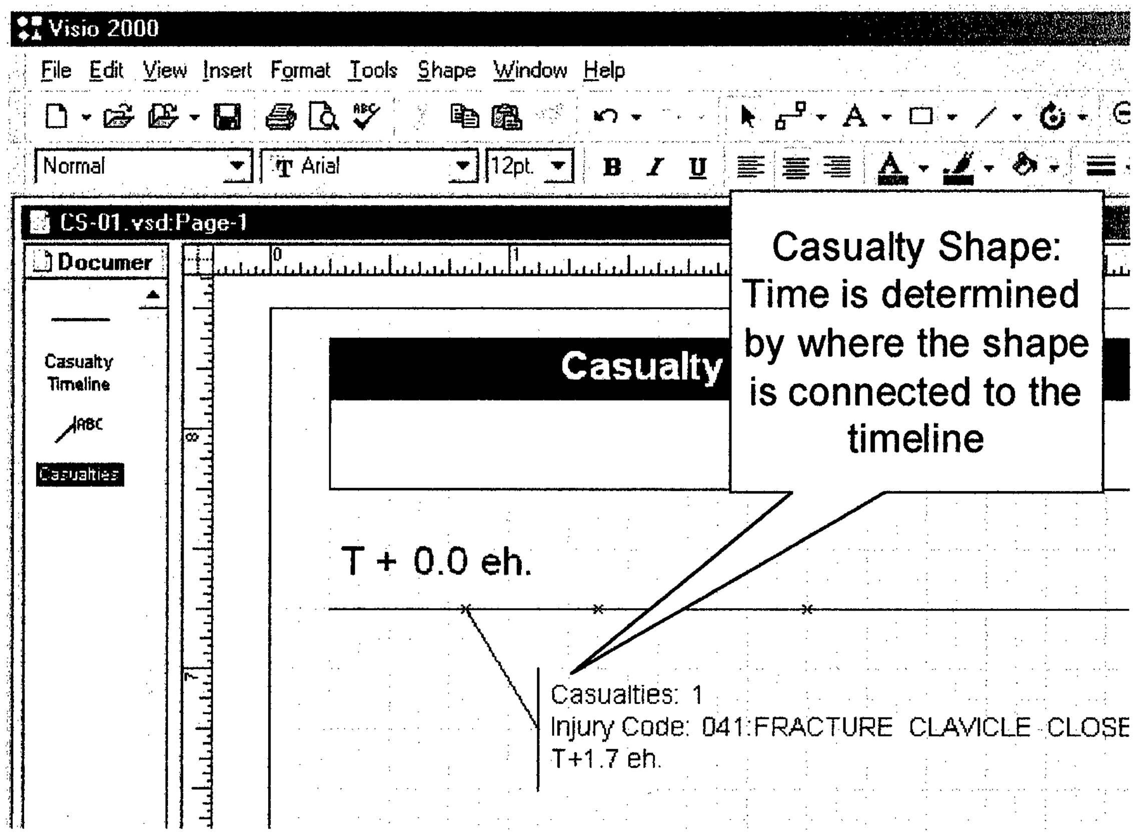


Figure 4-6 Casualty Stream Display

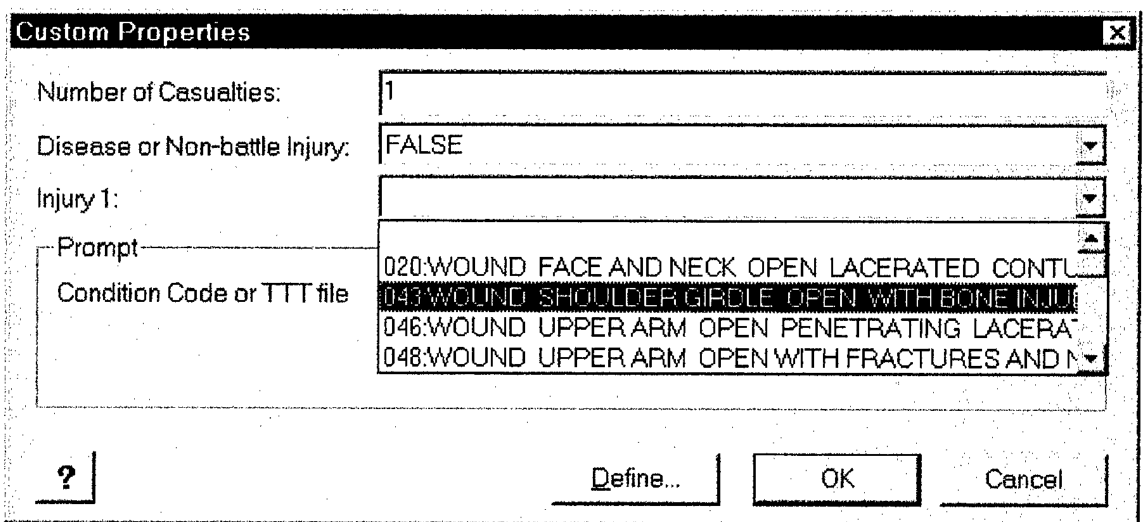


Figure 4-7 Casualties Dialog Box

Wizard-type Interface

The second interface is based upon Microsoft Wizard-type dialog boxes. It was incorporated into the tool to allow users to quickly make minor changes to the scenario configuration, the casualty stream information, and/or the MTF configuration. The wizard is useful if the user does not have Visio installed. The Simulation Engine and the Analysis Tool can be launched using the wizard.

Figure 4-8 is an example dialog box from the Wizard. This dialog box is used for MTF configuration changes, such as changes to the staffing level (by clicking on the "Staff Details…" button) or changes to the number of beds in the ward (by clicking on the "Component Details…" button). The user advances through the wizard by clicking the "Next" button.

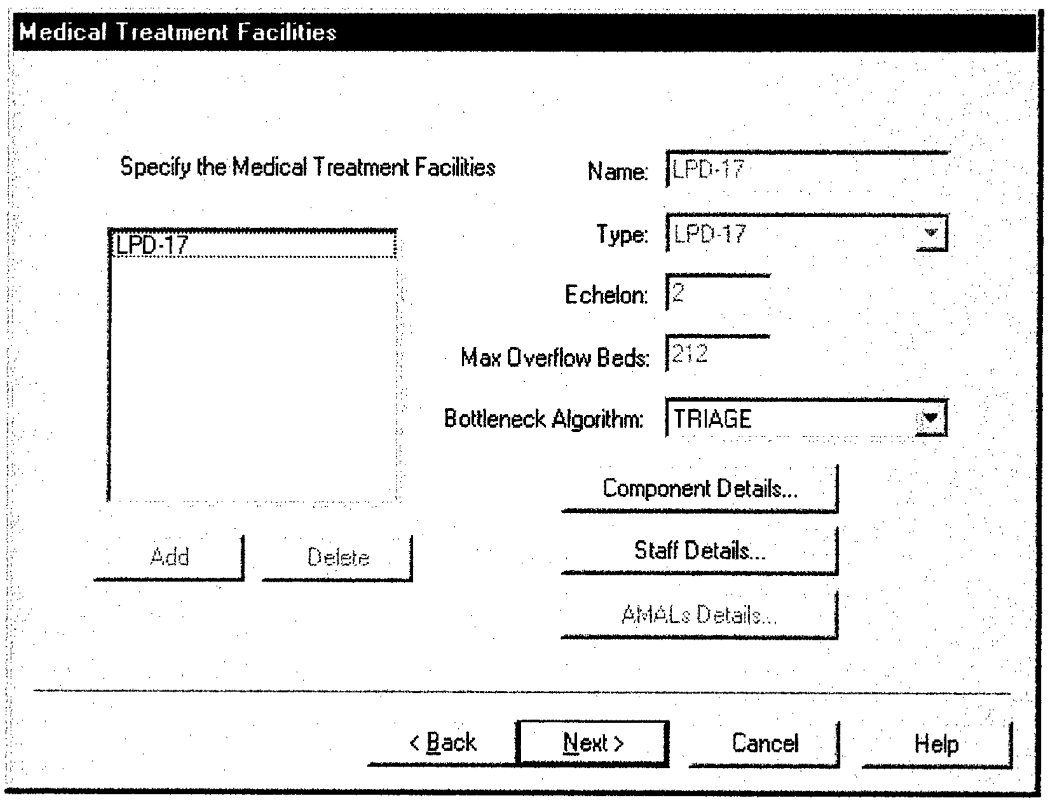


Figure 4-8 Wizard Dialog Box

Notice that the user has the ability to change the Bottleneck Algorithm. This algorithm defines how the Simulation Engine will choose the order that casualties are treated when a bottleneck has occurred. This topic is discussed in greater detail in the Simulation Engine section.

Database

Operation of CasFlow requires three sets of data, as shown in Figure 4-9. The CasFlowData Database includes the components, staffing, equipment, supplies, and transports that make up the MTF as well as the Casualty Stream information. The casualty stream table stores the details about the casualties that will present to the medical treatment facility during the simulation. The casualty stream can either be generated manually in the Graphical User Interface or computed using a stochastic model.

The TTT Database is a set of Task-Time-Treater data representing the treatment protocols for each injury indicated in the selected casualty streams.

The CasFlow Analysis Database contains the simulation results. This data is generated by the Simulation Engine, stored in the database, and then formatted and displayed by the CasFlow Analysis Tool.

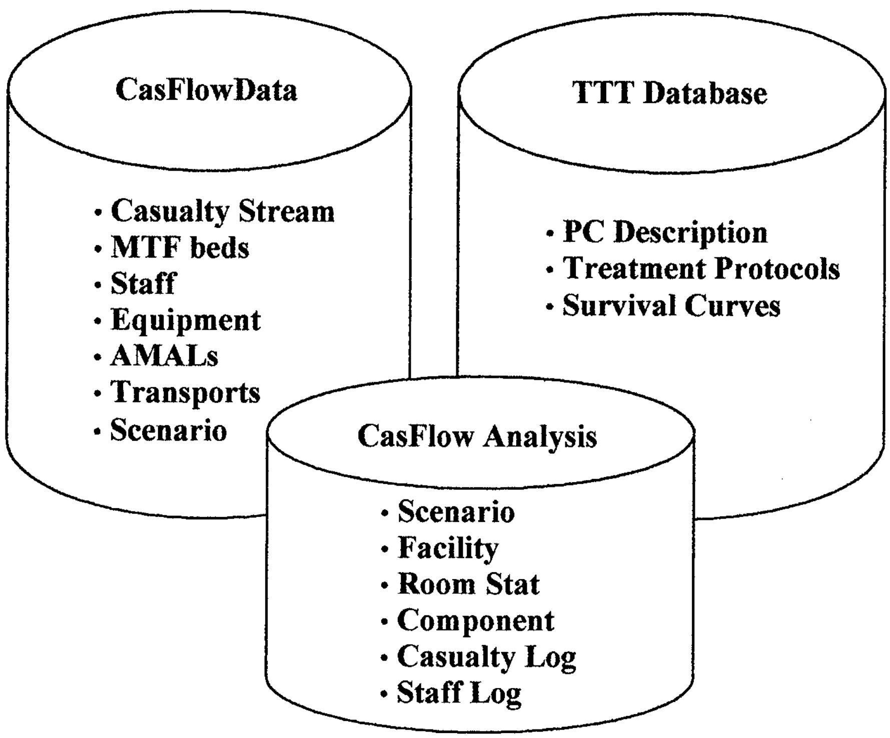


Figure 4-9 CasFlow Databases

CasFlowData Database

The CasFlowData database is built using Microsoft Access. This database is comprised of the following information:

- the components of an MTF such as number of operating rooms, x-ray machines, or ward beds,
- the equipment allocated to an MTF such as the type of x-ray machines,
- the consumable supplies allocated to an MTF such as the number of bags of ringers lactate,
- the staffing allocated for the MTF as well as possible staff substitutions, and
- transports.

Figure 4-10 shows the relationship between the different tables that comprise the MTF configuration database.

The MTF table lists the components that comprise the facility. This table is already populated with information for the following Navy class of ships: LPD17, LCC, AGF, CVN, LHA, LSD, LHD, LPD, CV, TAH, LST, and MCS. As MTFs are created and edited using the User Interfaces this table is updated accordingly by the User Interface software.

The three staffing tables (Staff Collection, Staff, and Staff Substitution) describe the allocated staff to a particular type of MTF (such as LPD-17 or LCC-19) and possible staff substitutions. The Staff Substitution table also contains an efficacy factor that is used by the Simulation Engine to degrade the care of the casualty if a substitute treater is used. The Staff Collection table is already populated with information for the following Navy class of ships: LPD17, LCC, AGF, CVN, LHA, LSD, LHD, LPD, CV, TAH, LST, and MCS.

The supplies allocated to each type of MTF are derived from the MTF to KIT, the KIT to NSN, and the NSN Description tables. The AMAL kits assigned to each type of MTF are listed in the MTF to KIT table. The KIT to NSN lists the individual items comprising each kit, and the NSN Description table describes those individual items.

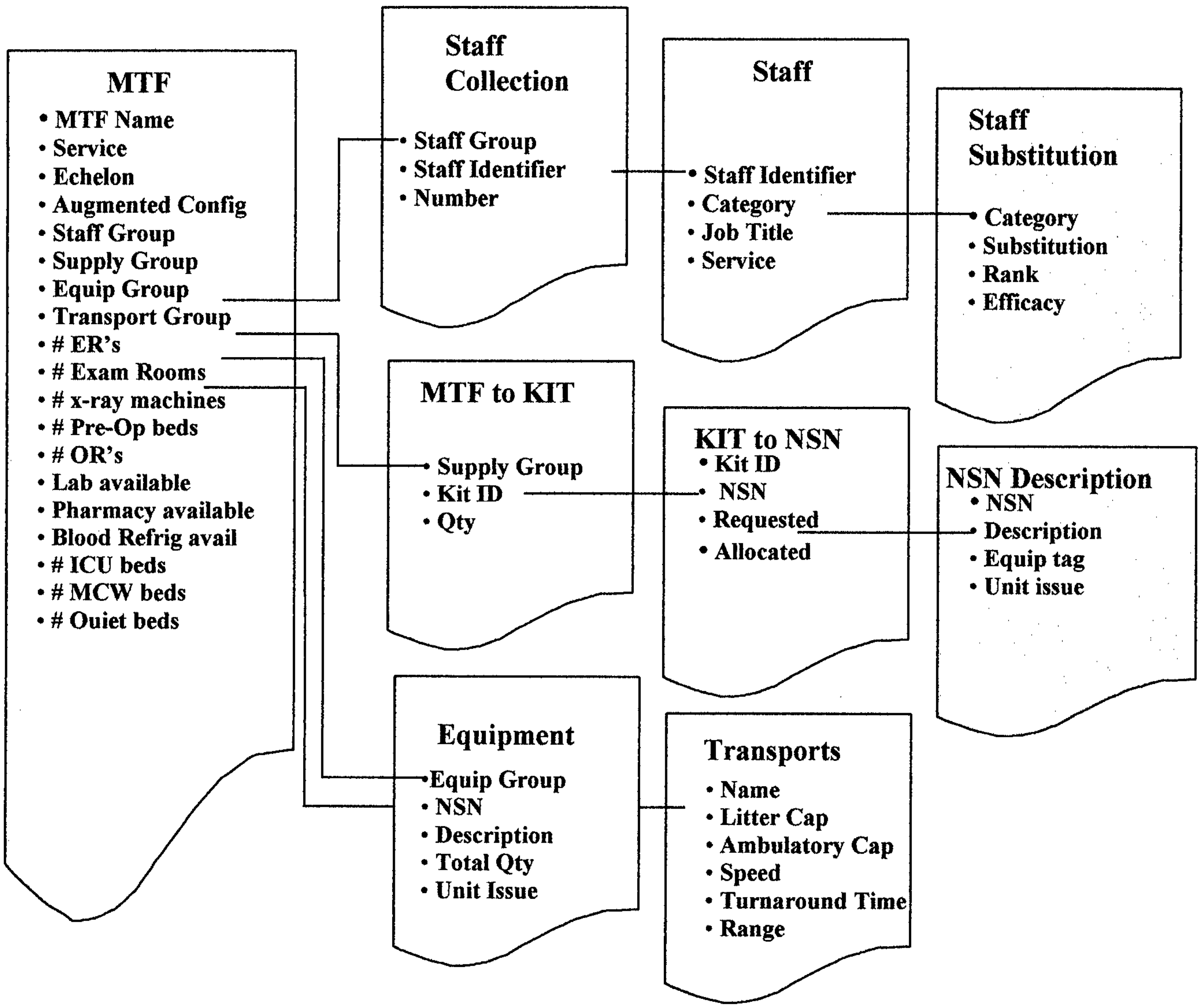


Figure 4-10 CasFlowData Database Tables

The casualty stream table is also a part of the CasFlowData Database and contains the following information: a casualty ID, a casualty stream ID, the time the casualty presents to an MTF, indicator of whether the injury is a DNBI-type injury; and the patient condition code of each injury. The casualty stream information generated when using the graphical or wizard-type User Interface is written to this table by the User Interface software. There is no need for the CasFlow user to input data to this table manually via Microsoft Access.

Figure 4-11 shows the detailed information contained in the casualty stream table.

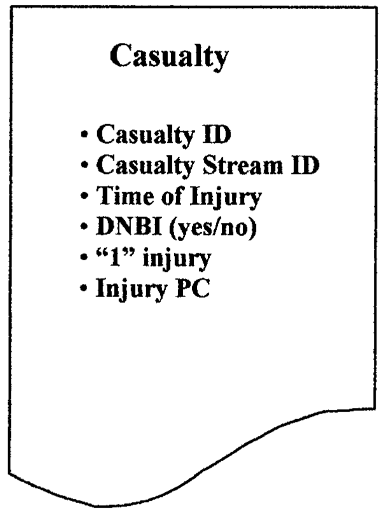


Figure 4-11 Casualty Stream Table

TTT Database

A treatment protocol is a database of information describing the treatment required, where it is performed, the staff required for the treatment, equipment, supplies (fluid, blood, and x-ray products), the time required, and other pertinent information for a variety of injuries and illnesses. The treatment protocols supported by CasFlow are derived from the DMSB/JRCAB database. The DMSB/JRCAB database supports about 350 patient conditions from which 19 have been selected for inclusion in the treatment protocols database. Although ScenPro did received JRCAB's latest database (Version 1.1), it was received too late (December 1999) to be included in the final release of the software.

The treatment protocols database is built using Microsoft Access and defines the time, bed, staff, equipment, and the material needed for each treatment (or task) listed for each Patient Condition (PC). This database also contains the USUHS Survival Curves used by the Simulation Engine to simulate mortality. This feature is described in greater detail in the Simulation Engine section.

The relationships between the treatment protocols database tables are shown in Figure 4-12.

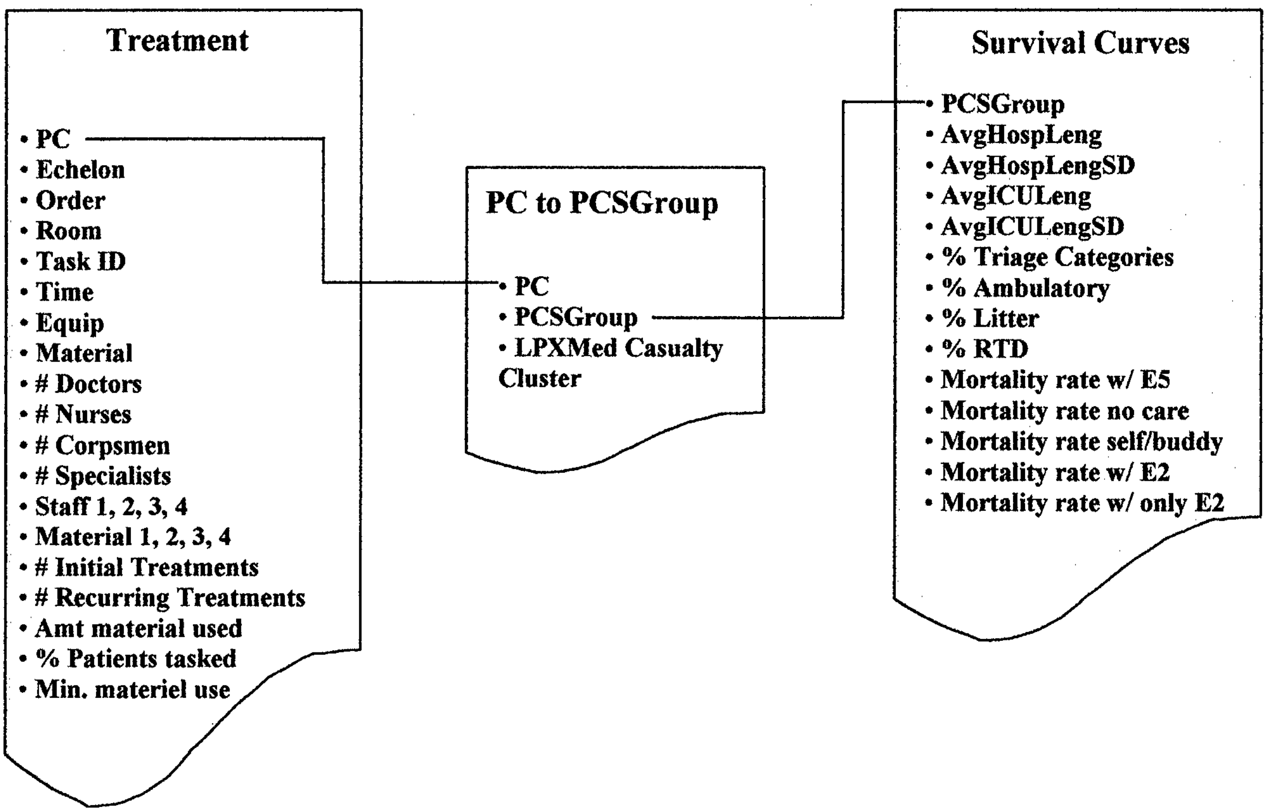


Figure 4-12 TTT Database Tables

CasFlowAnalysis Database
The CasFlow Analysis database contains the statistics generated by the Simulation Engine, such as the time a corpsmen spent in the casualty clearing area or the amount of blood casualties consumed in the triage area. The CasFlow Analysis Tool then reads this data and (using Microsoft Excel) converted to PivotTables for quick and easy analysis by the user.

Simulation Engine
CasFlow contains a fast discrete event simulation engine. To provide broad reuse, this engine was developed as a Dynamic Link Library (.dll). The events monitored by the engine include casualty generation, transport arrivals and departures, treatment protocol task completion, mortality, staff work hours, and casualty condition downgrades.

The Simulation Engine reads the scenario definition (created with the User Interface), sets up the MTF configuration (based on the MTF configuration database), and "moves" the simulated casualties through the facility. Each casualty follows the treatment profile defined in the treatment protocol database. When a casualty gets to a room (such as the x-ray room), the Simulation Engine collects the allocated staff, the allocated consumable supplies, and equipment necessary to perform the treatment task. If any of the requirements are missing (such as if the x-ray machine is already in use), the casualty waits. When the task is completed, the patient "moves" to the next task defined in the treatment protocol, and the resources are released for use by the next casualty.

The system is designed to minimize patient movement. In other words, once a casualty gets into a bed, the casualty stays there until their need for that bed ends. This is true even if a casualty waiting for that bed type is of a higher priority. This logic is true in the real world.

The Simulation Engine uses the USUHS survival curves to simulate mortality. Each time a casualty arrives at an MTF random numbers are used to determine if the casualty will survive the treatment plan. If the casualty will not survive, a random number is used to determine the amount of time the casualty will live. If the casualty is still in the MTF being treated after the time has expired, then the casualty dies.

There are four ways in which the user can control the order in which patients are treated:

1) Based upon the triage level;
2) First In First Out (FIFO);
3) Last In First Out (LIFO);
4) Patient with the shortest treatment time will be treated first.

As the simulation runs, the Simulation Engine captures and records patient movement and resource usage in Microsoft Access tables.

Event Checker

Every clock tick, the Event Checker looks through the events in the Event List to see if any events occur at this time. There are currently three types of events:

- Casualty Generation
- Mortality Curve-based Death
- Treatment completion events

The Event Checker keeps tabs on when casualties present at the medical treatment facility. A casualty's presentation time is stored along with their injury code in the casualty stream table in the CasFlowData database.

Each casualty has a value associated with it corresponding to his or her time of death. For many casualties, this value is set to infinity, for others it is a finite time. If the casualty is still in the medical treatment facility when their mortality time is reached, the CasFlow simulation engine kills the casualty.

When a treatment is completed, the Event Checker updates the patient's status, stores statistics about the time the patient was in treatment and the supplies used, and, in most cases, frees up the space, staff, and supplies. Unless the patient needs to stay in the same space (in which case a Preference Flag is set), an event is created showing that the casualty is being moved to the space (or the waiting room for the space) indicated by the next Treatment Protocol entry.

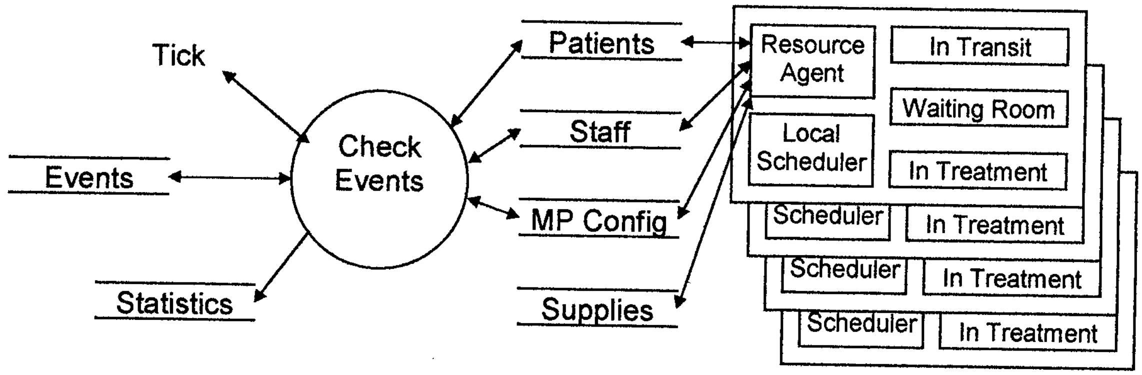


Figure 4-13 Simulation Engine Internals

When a movement is completed, the Event Checker updates the patient status and the waiting room area status of the new space.

The Event Checker then kicks off the Local Scheduler for each space that has changed status, in priority order (OR, X-Ray, Dental, Exam Room, Assess and Sort, and Wards).

Local Scheduler

The Local Scheduler is responsible for maximizing patient flow through its component while trying to give resources to the sickest patients first. To accomplish this, the local scheduler keeps track of all patients who are waiting for the resource. These patients are sorted by:

- Triage Level
- Preference Marker
- Room Specificity

Note, a Preference Marker is set when a patient is already in the room. This gives the patient preference over other patients. The reasoning is that it is somewhat simpler to perform a task on a patient who is already in the room than to move that patient out and another in. Also note that the other resource types, equipment (not associated with a room) and staff do not currently have Preference Markers.

Note, Room Specificity tries to capture the idea that some patients request a room because they need ANY room while others request a room because they need that exact room. Patients who need that exact room should have priority over those who need any room.

After the patients are sorted, the Resource Agent is queried to find out the earliest possible availability of resources for the first (highest sorted) patient. If all of the resources are currently available for the first patient, that patient is moved from the Waiting Room queue to the In Treatment queue, the resources are flagged as in use, the patient's status is updated, and an event is created for the time when the treatment will end.

If the first patient's resources are not available, the Resource Agent is queried for each of the other patients (in priority order) until one is found which has all of its resources and can complete before the first patient's resources become available. If such a patient is found, that patient is moved from the Waiting Room queue to the In Treatment queue, the resources are flagged as in use, the patient's status is updated, and an event is created for the time when the treatment will end.

CasFlow Analysis Tool

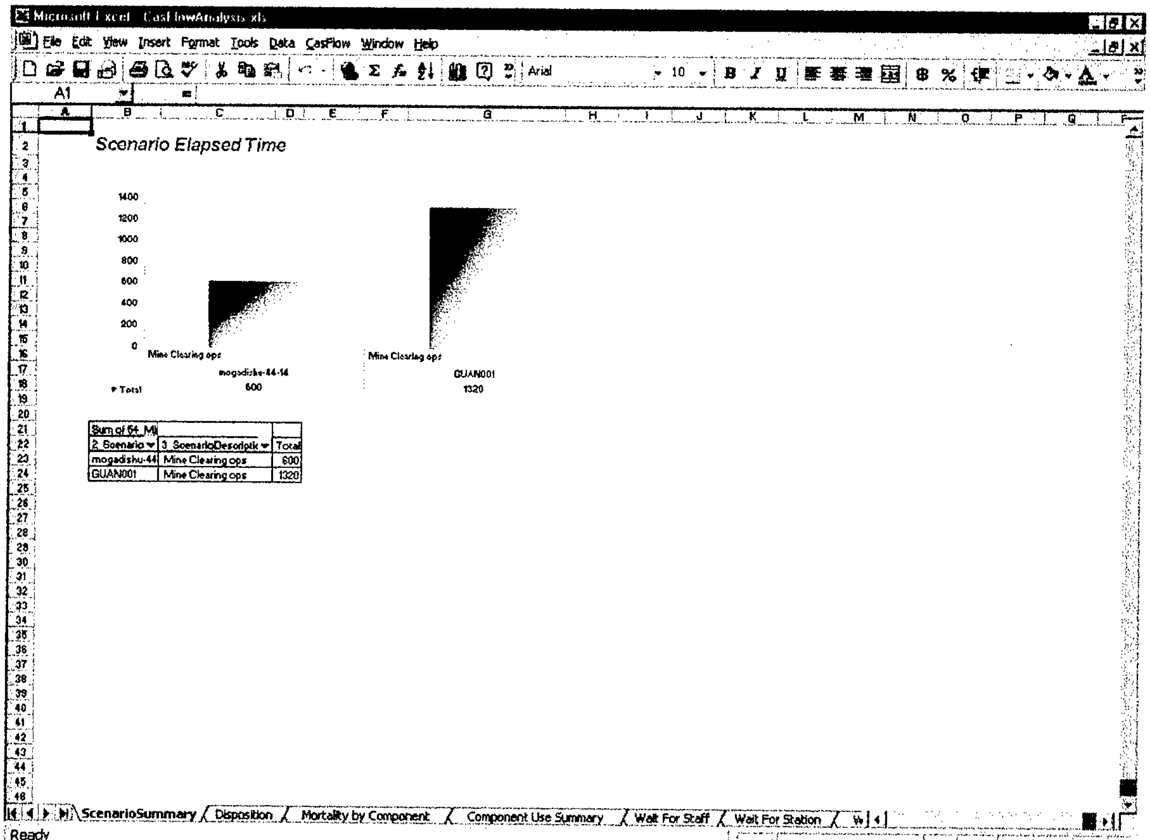
Once the simulation is complete, analysis is performed by a customized version of Microsoft Excel™ referred to as the CasFlow Analysis Tool. This tool reads the Access database tables created by the Simulation Engine and analyzes the data to create a set of metrics. These metrics indicate whether or not the selected MTF configuration will support the casualty stream. The metrics generated include mortality, wait time for staff and rooms, supply usage, staff utilization, component usage, and scenario summary information. In all, CasFlow creates 12 PivotTables capable of providing the multitude of perspectives required to perform powerful "what if" analyses.

After the results of a particular configuration are analyzed, the simulation can be re-run with a slightly different configuration and the results can be compared. Additionally, CasFlow users can apply their own "costing function" to the simulation results to optimize the design of an MTF in order to maximize their allocated funds.

The following PivotTables represent the CasFlow Analysis Tool output for CasFlow.

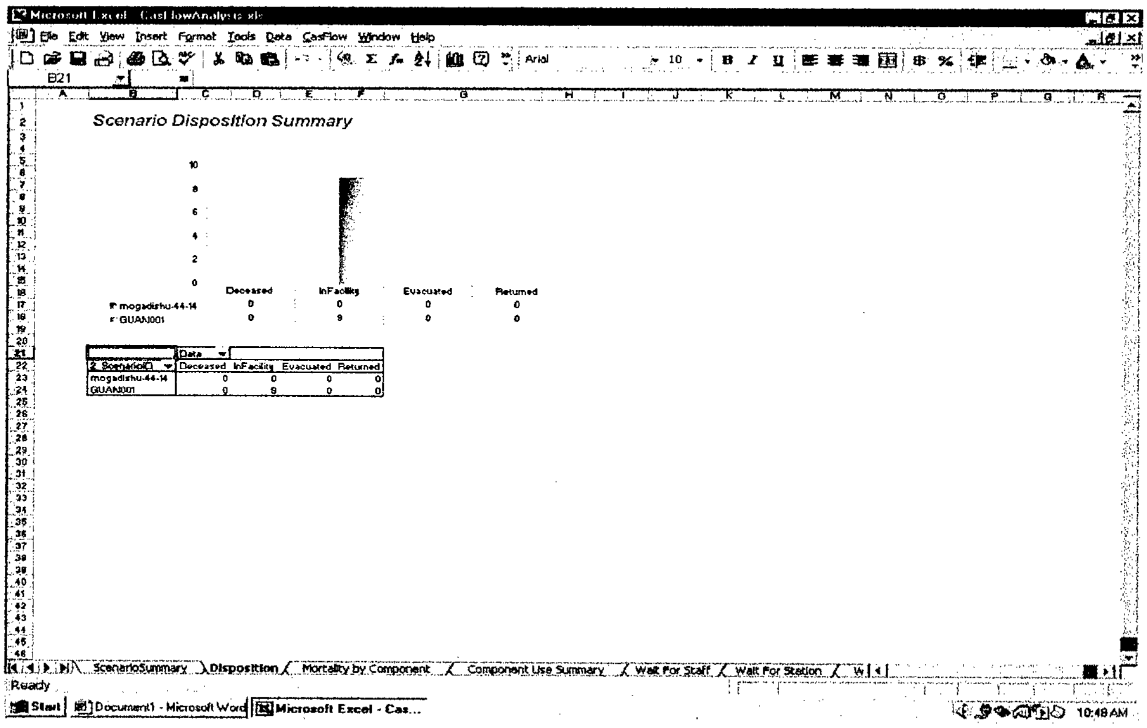
Scenario Elapsed Time

This PivotTable indicates the amount of time (in minutes) of the duration of the scenario(s). The user can add or delete a scenario to analyze via the pull-down provided on the display. In this example, the Mogadishu scenario was designed to cover a 600-minute timeframe and the Guan001 scenario was designed to cover a 1320-minute timeframe.



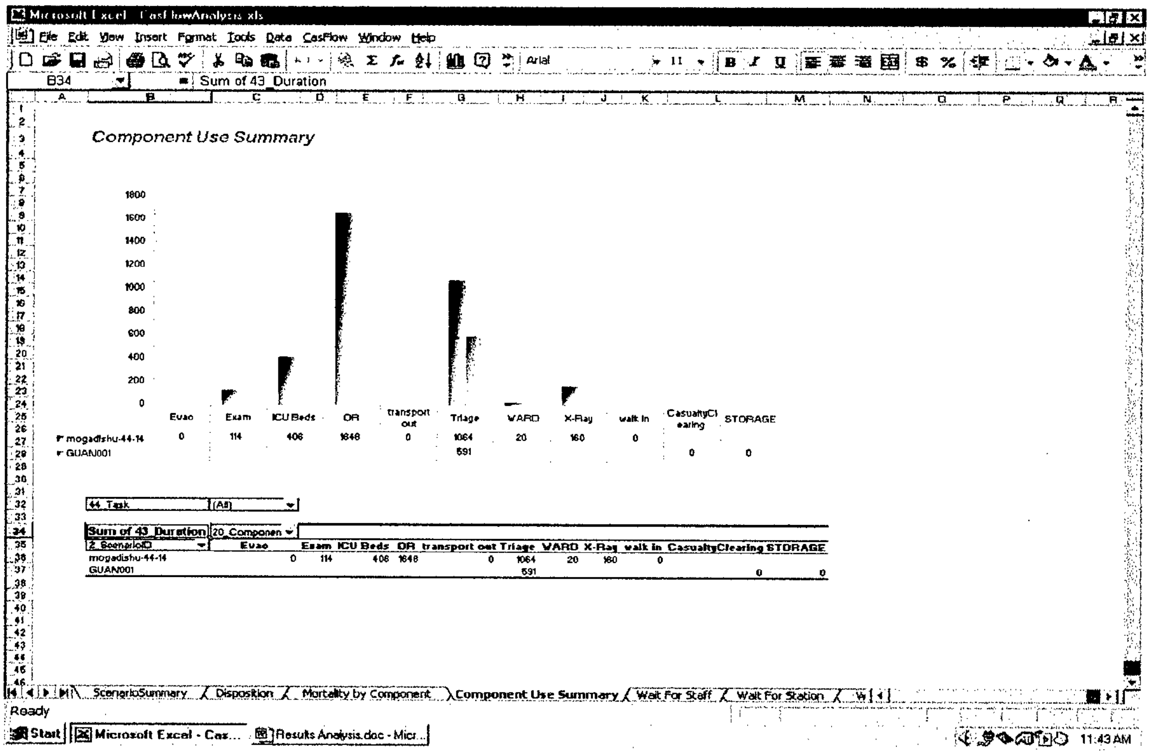
Scenario Disposition Summary

This PivotTable indicates the disposition of the casualties treated during the scenarios. The categories logged by the CasFlow Analysis Tool include deceased, treated in facility, evacuated, and returned to duty.



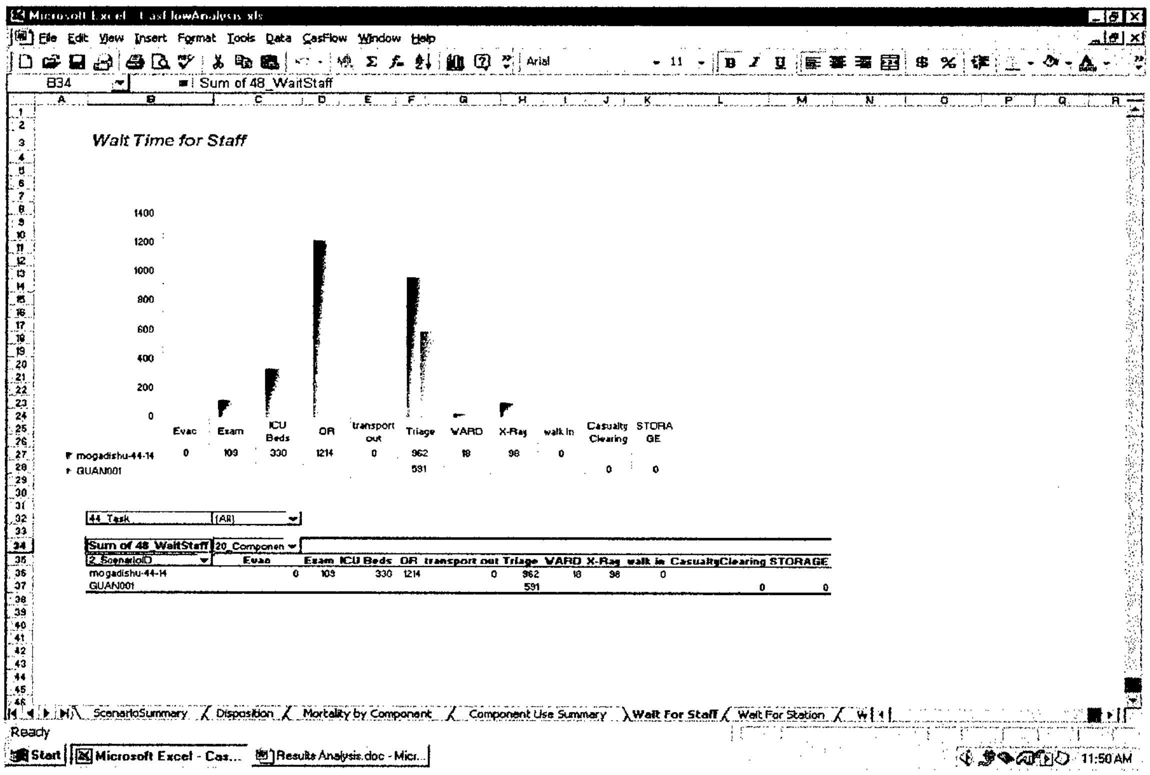
Component Use Summary

This PivotTable indicates the amount of time (in minutes) each component of the MTF was occupied. In this example, the triage area was occupied 1064 minutes during the Mogadishu scenario and 591 minutes during the Guan001 scenario.



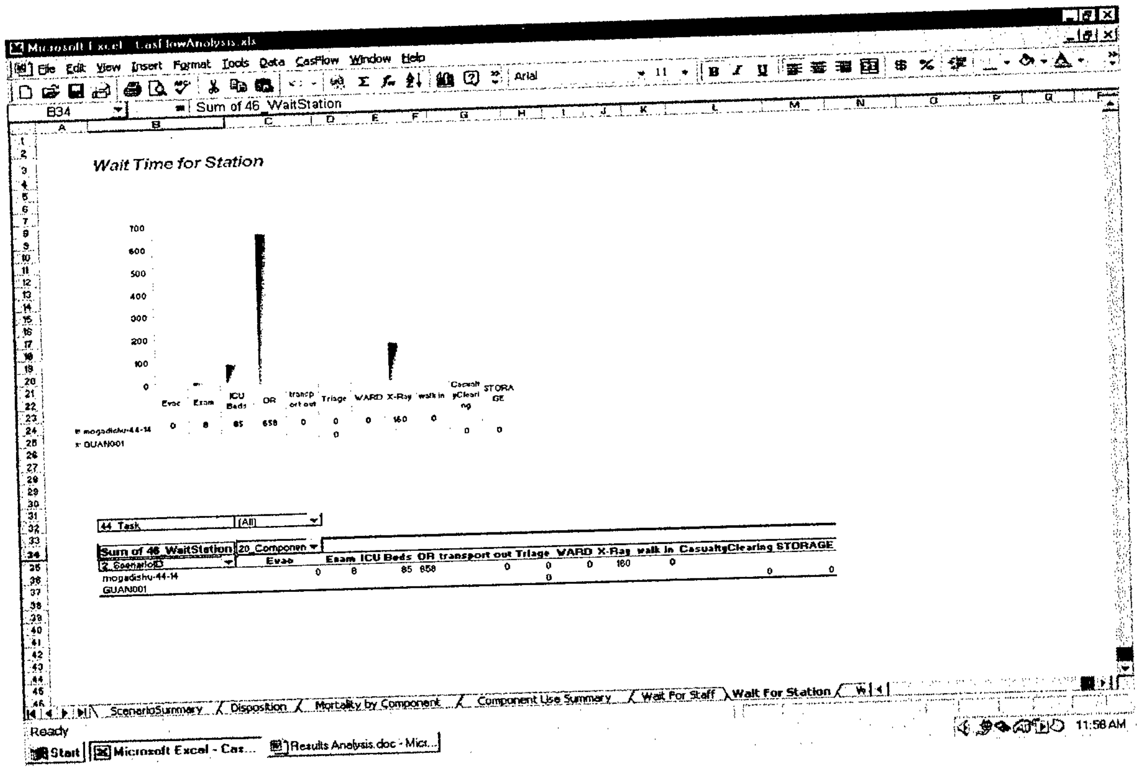
Wait Time for Staff

This PivotTable shows how many minutes patients had to wait for available staff in each component of the MTF. In this example, the longest wait period was in the operating room during the Mogadishu scenario and in the triage area during the Guan001 scenario.



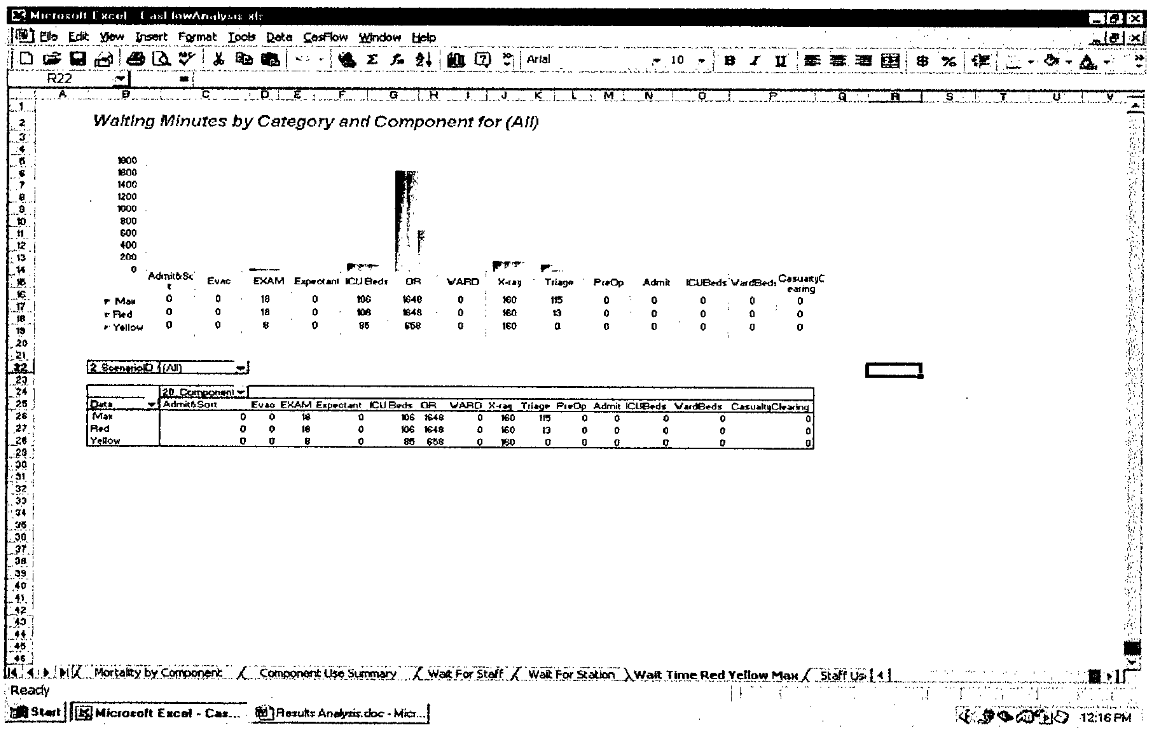
Wait Time for Station

This metric indicates the number of minutes casualties waited for beds. In this example, the longest wait for the Mogadishu scenario was for an operating room. The casualties in the Guan001 scenario never waited due to a bottleneck with beds.



Waiting Minutes by Category and Component

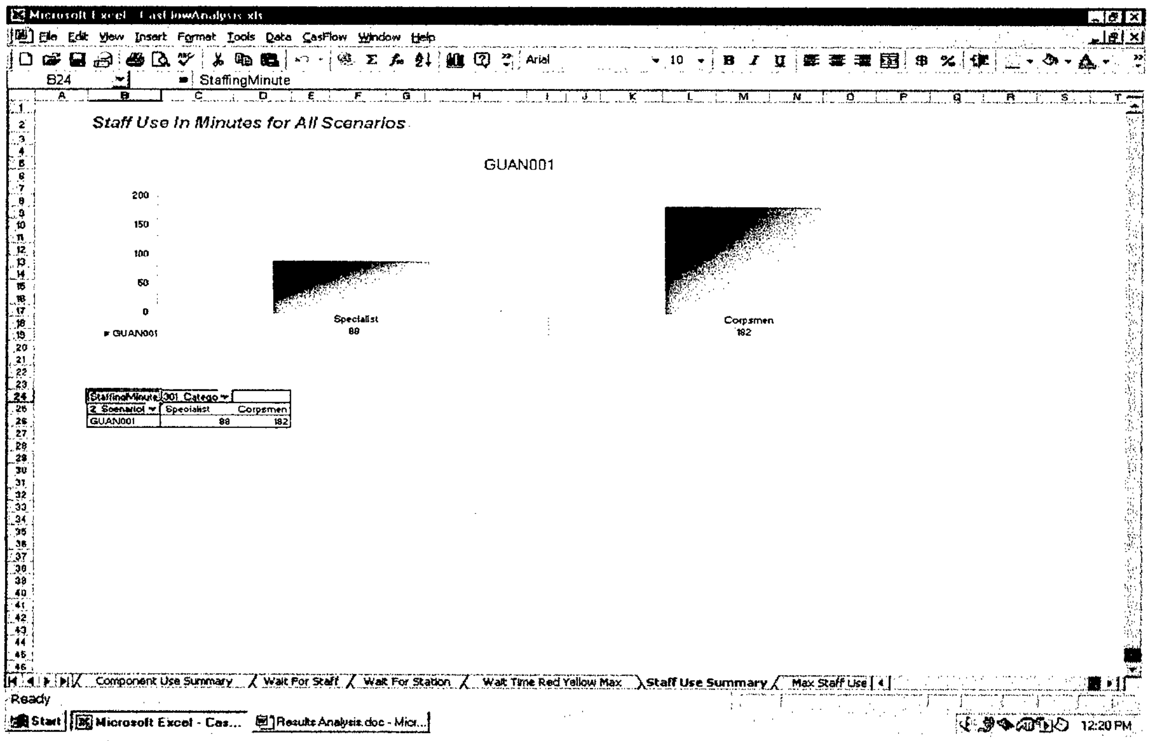
This metric shows a breakdown (by category) of the wait time for each component of the MTF. In this example, the "All" means that the waiting minutes for each category were combined for all scenarios under consideration by CasFlow. The "Max", "Red", and "Yellow" represent threshold levels where maximum indicates that the waiting area was 100% full, red represents a 90% to 99% full waiting area, and yellow represents an 80% to 89% full waiting area. This metric is a combination of waiting times and does not indicate how long a particular casualty waited. For example, the OR had a maximum wait time of 1648 minutes, a red wait time of 1648 minutes, and a yellow wait time of 658 minutes. This means that the waiting area for the OR was filled to the maximum for 1648 minutes. This PivotTable is useful for identifying system bottlenecks.



Data	Admit&Sort	Evac	EXAM	Expectant	ICU Beds	OR	VARD	X-ray	Triage	PreOp	Admit	ICUBeds	WardBeds	CasualtyClearing
Max	0	0	18	0	106	1648	0	160	115	0	0	0	0	0
Red	0	0	18	0	106	1648	0	160	13	0	0	0	0	0
Yellow	0	0	8	0	85	658	0	160	0	0	0	0	0	0

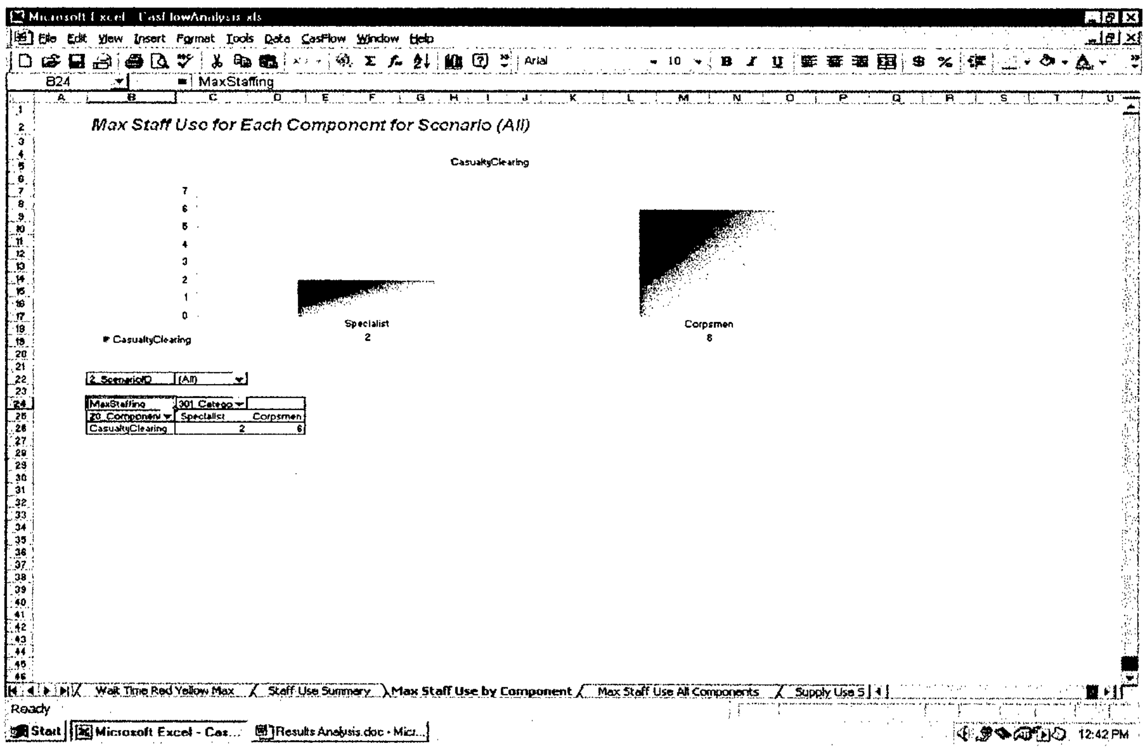
Staff Use In Minutes

This PivotTable indicates the time (in minutes) of the personnel used in a scenario. The user can add or delete staff categories via the pull-down provided on the display. In this example, the user can analyze the amount of time specialists and corpsmen are used in the Guan001 scenario.



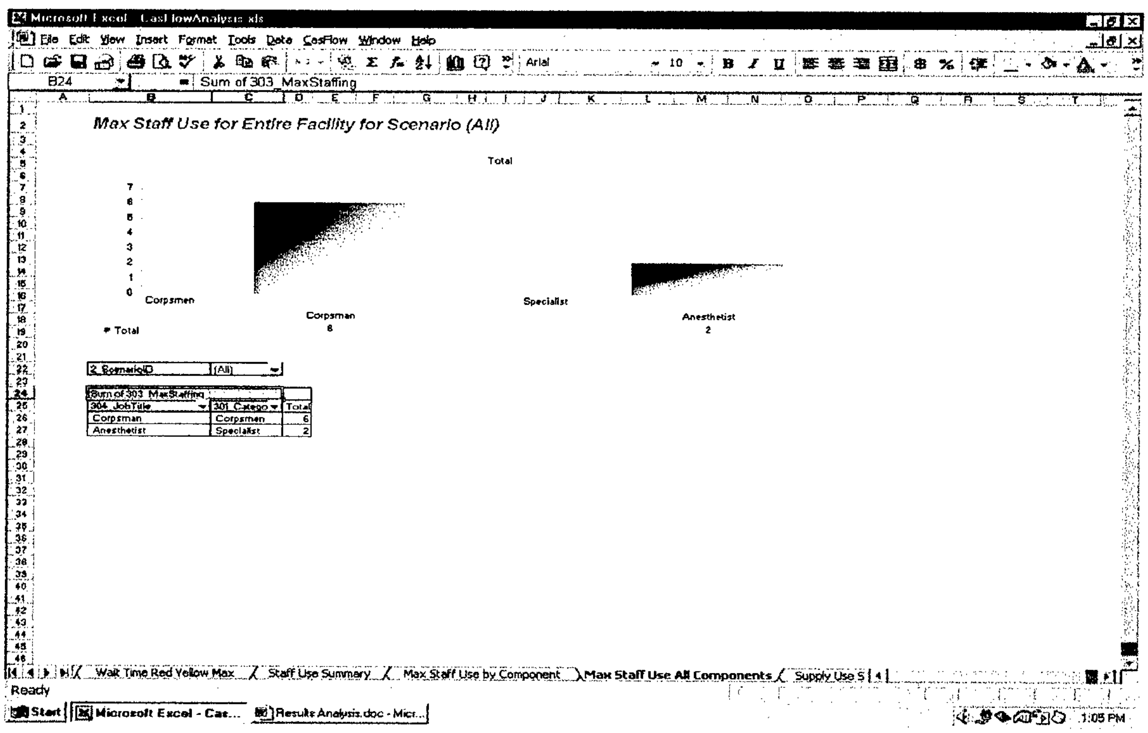
Max Staff Use for Each Component

This PivotTable is used to view the maximum staff usage at any time in any component in the MTF. The pull-downs allow the user to pick the component type and the scenario to display. In this example, the user is analyzing the maximum staff used in the casualty clearing area for all scenarios under consideration by CasFlow. Note that at most, two specialists and six corpsmen were used. When "all" scenarios are chosen, the Analysis Tool sums the numbers from each scenario.



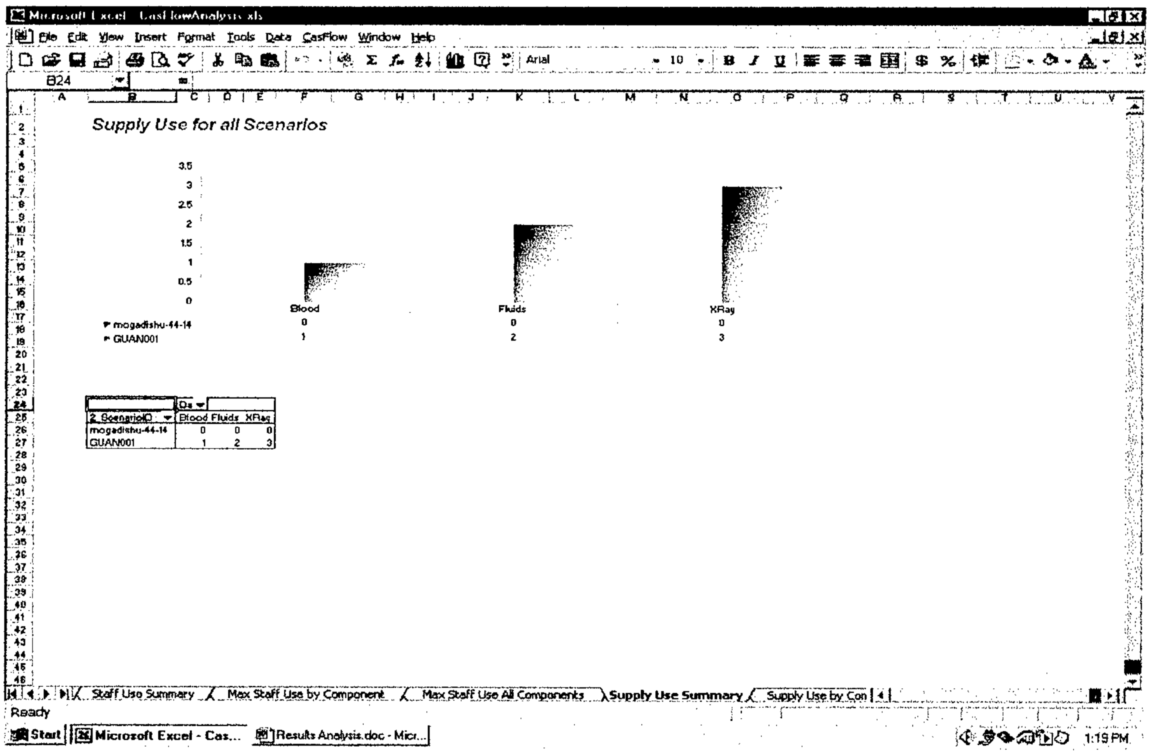
Max Staff Use for Entire Facility

This PivotTable indicates the maximum number of personnel by category used at any one time in the entire facility. The user can add or delete the staff categories via the pull-down. In this example, the user is analyzing all of the scenarios so the staff numbers are summed.



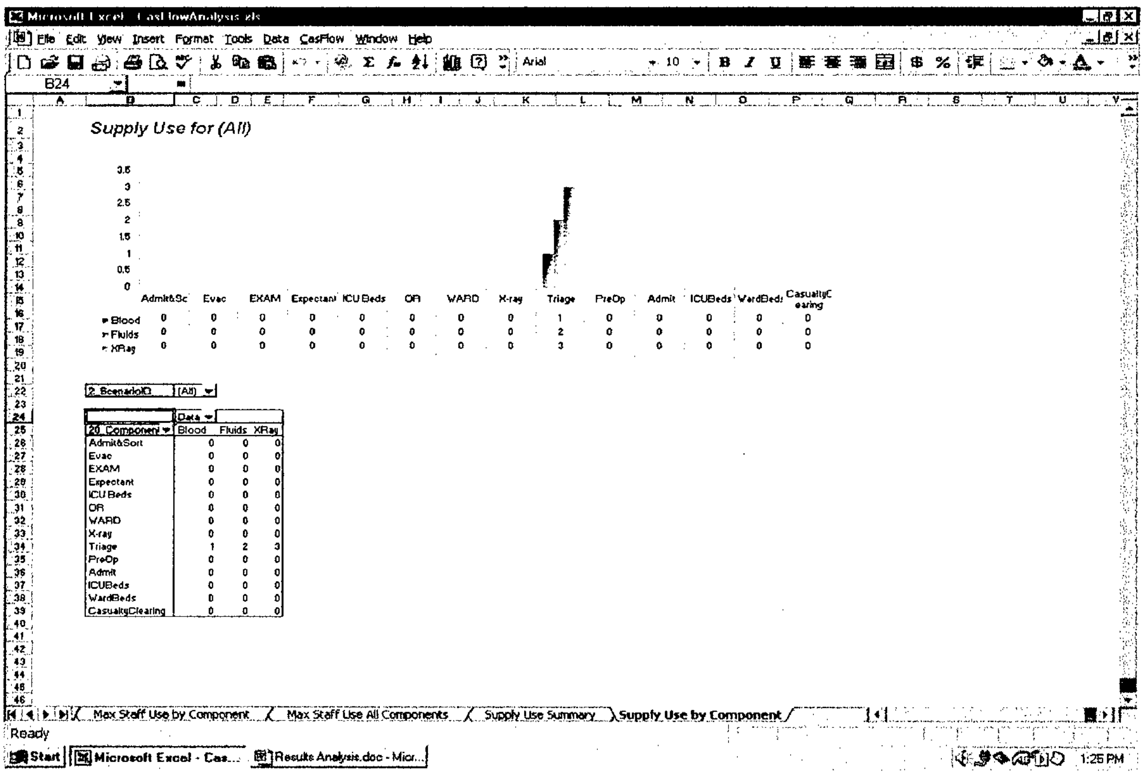
Supply Use Summary

This PivotTable is used to determine the total amount of blood, fluids, and x-ray products consumed for each scenario the user chooses to analyze. In this example, the Gaun001 scenario used 1 unit of blood, 2 units of fluid, and 3 units of x-ray products.



Supply Use By Component

This PivotTable breaks down the blood, fluid, and x-ray supply usage by MTF component. In this example, the usage amounts were combined for the two scenarios (Mogadishu and Guan001). The table indicates in this scenario that most of the tracked supplies are used in the triage area.



5.0 Activities

In addition to the Kick-Off meeting and the various status meetings held in Washington DC or San Diego, CA, ScenPro has made a number of other presentations related to CasFlow.

9/9/1997 – Held Kick-Off Meeting with Bill Pugh in San Diego, CA
11/5/1997 – Attended Comprehensive HLA training in Austin, TX.
11/20/1997 – Gave Technical Review to Dennis McBride in Washington, D.C.
12/22/1997 – Gave Technical Review to Dennis McBride in Washington, D.C.
2/22/1998 – Gave Technical Review of CasFlow.
3/11/1998 – Gave review of CasFlow to RADM Phillips in Washington, D.C.
4/14/1998 – Install CasFlow for Young, Pugh, and Hardy in San Diego, CA
6/1/1998 – Attended DIS/HLA review in Washington, D.C.
6/24/1998 – Attended KA session with Dennis Moses in San Diego, CA
8/24/1998 – Gave a technical review to Bill Pugh in San Diego, CA
8/25/1998 – Described to Doug Hardy how to make CasFlow HLA Compliant
10/18/1998 – Gave a technical review to Bill Pugh in San Diego, CA
10/21/1998 – Aid Pugh demonstration of CasFlow to LPD-17 War Room in Norfolk, VA
10/25/1998 – Attend DMPILS-99 War Game Conference in Hagerstown, VA
7/7/1999 – Attended Doug Hardy's JMedSAF meeting in San Diego, CA
8/29/1999 – Attended the CUD Requirements Meeting in Frederic, MD
1/13/2000 – Attended meeting of medical planners in San Antonio, TX

LPD-17 War Room Presentation

Bill Pugh gave a technical review of CasFlow and a presented a summary of the LPD-17 results to a gathering of medical planners in the LPD-17 War Room.

DMPILS-99 Conference

Michael Gately was invited by Bill Pugh to attend the DMPILS-99 Wargaming conference. DMPILS is an annual gathering of logisticians to plan for possible changes in warfare. At this particular conference, a Mogadishu-like scenario was played out using assets available in 1999, 2005, and 2010.

At the conference, Mr. Gately became a member of the 2010 team and used CasFlow to determine the impact of deploying the LPD-17 in an Amphibious Ready Group. The tool was well received by the other members of the 2010 team.

CUD

Bill Pugh invited Michael Gately and Sharon Watts (ScenPro, Inc.) to attend the Common User Database (CUD) Requirements Meeting. At this meeting the future of

Task-Time-Treater files was discussed. Mr. Gately was a part of the Planning team and used his experience on CasFlow to make valuable comments to the team.

It is hoped that when the CUD is eventually available, tools such as CasFlow will become much more robust and capable – enabling more accurate design, planning, and training.

JMedSAF

In July 1999, Bill Pugh invited ScenPro to attend a JMedSAF meeting being hosted by Doug Harry. Eleven months earlier Dr. Jim Mantock and Michael Gately had made a presentation to Mr. Harry describing how to modify CasFlow to create a tool that could become the medical component of a High-Level Architecture simulation (see Figure 5-1).

The JMedSAF tool was a different tool designed for the same purpose, to add Joint Medical Synthetic Forces to a DIS/HLA simulation. At the meeting Mr. Gately provided a variety of suggestions for the tool. Additionally, Mr. Gately provided the JMedSAF team the UHSUS Mortality data developed under CasFlow funding.

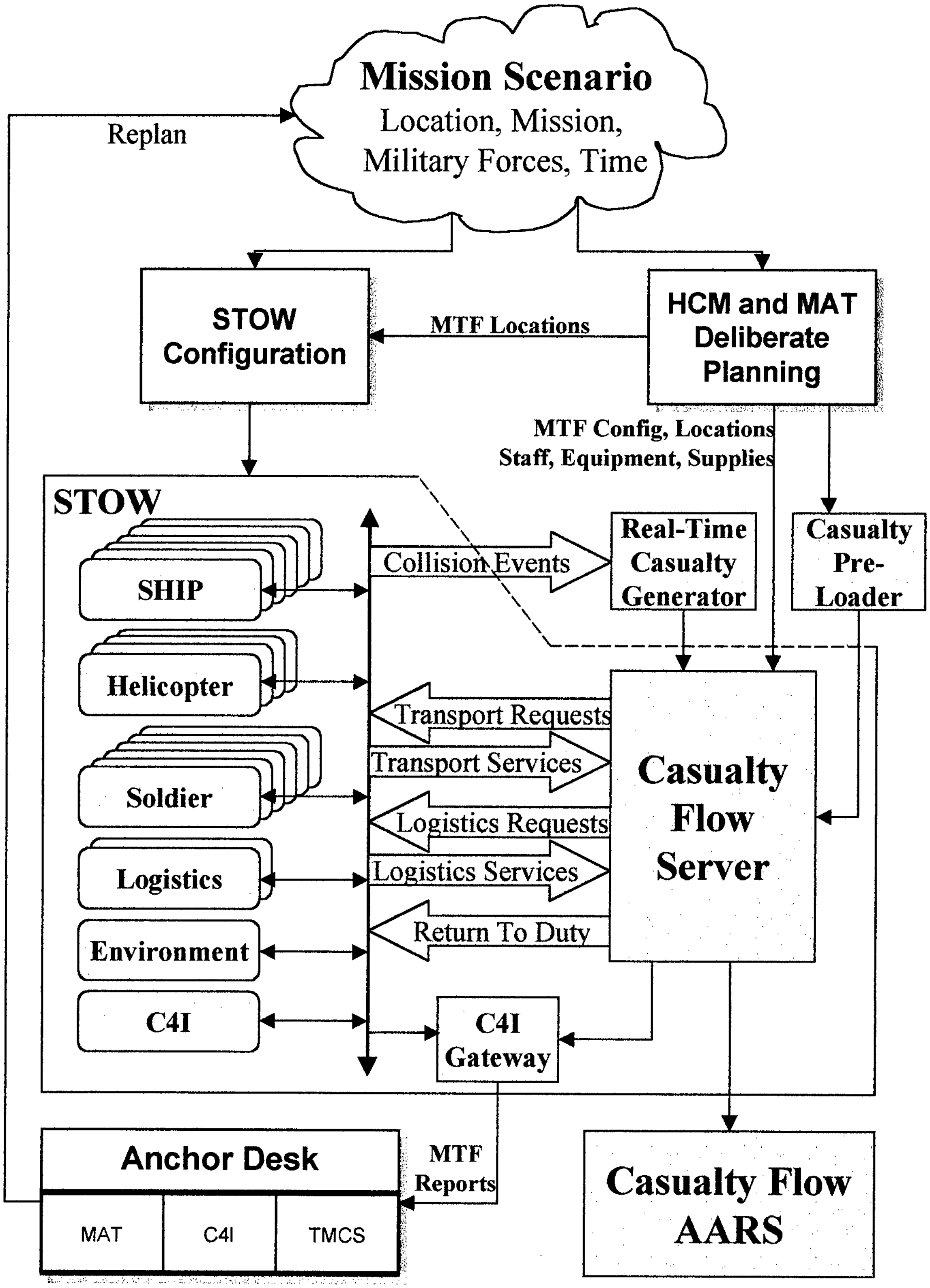


Figure 5-1 Proposed JMedSAF Mission Planning and Rehearsal Implementation

6.0 Additional Development

NavMedWatch for the US Navy

NavMedWatch is a proposed Real-time/Predictive Medical Data Fusion Watchboard for use by the US Navy to enhance and improve medical readiness. The Phase I effort for this contract has been completed and a Phase II proposal has been submitted.

NavMedWatch will provide streamlined data to Navy medical care providers, support personnel and remote command staff allowing for the rapid visualization and assessment of the tactical medical situation. The key functions of the system include:

- Tracking of patients and medical personnel at the MTF and JTF levels;
- Tracking bed/room availability, Class VIII-A supplies, and blood supplies at the MTF and JTF levels;
- Tracking DNBI data and providing access to epidemiological predictions at both levels;
- Predictive simulation capability to identify bottlenecks within the medical system;
- An intelligent agent to provide suggested alternatives to alleviate the identified bottlenecks.

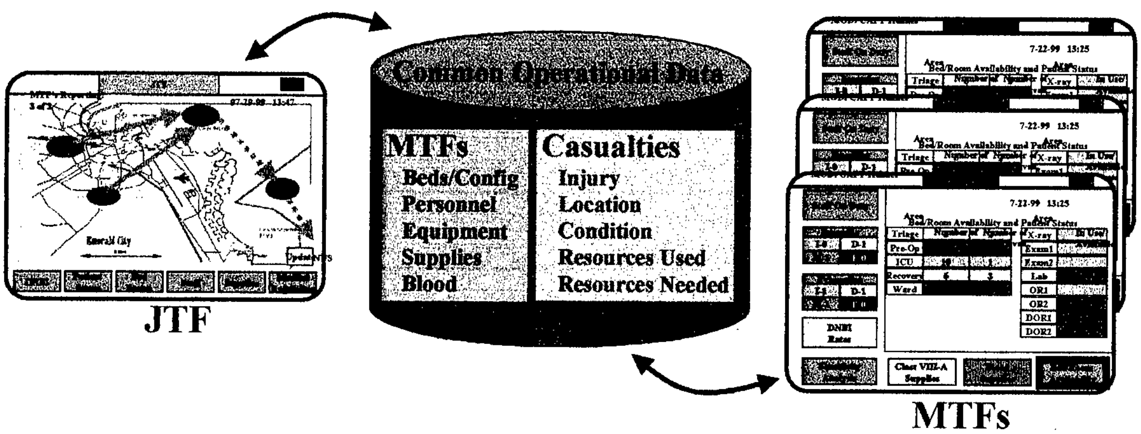


Figure 6-1 NavMedWatch Common Operation Data

The NavMedWatch display is designed to include graphical, textual, and color coding of relevant data for quick and easy interpretation and analysis. The tool is designed to gather data from existing sources including TMCS (Theatre Medical Core Services), FMSS (Field Medical Surveillance System), pre-configured databases, and Internet Repositories, as well as from future sources such as personnel status monitors, personnel locators, and Personal Identification Cards.

The proposed system includes a simulation capability (CasFlow) for predicting casualty movements and resource consumption. From this simulation, potential resource shortfalls can be identified. Intelligent interviewing agents are included to offer suggestions for resolving the identified resource shortfalls.

NavMedWatch also has the capability to record and store pertinent data captured during medical incidents or exercises. Thus the NavMedWatch Tool can be used to support medical training activities and after-action reviews. As an after-action review tool, NavMedWatch enhances the training of medical care providers, medical regulators, and medical planners by providing realistic collective data.

Chemical / Biological Incident Response Tool for the US Air Force

In order to insure low mortality in the event of a chemical or biological warfare incident, it is critical that the proper medical resources be available to the medical staff when they are needed. One approach to doing this is to pre-position all necessary resources for all possible incidents. Current policy prevents this level of expense.

The solution proposed by ScenPro for the Chemical /Biological Incident Response Tool (CBIRT) is to use discrete event simulation to predict the future resource use based upon an actual incident. The Predictive Casualty Management Simulation (PCMS) takes the current medical status of an incident and, using medical treatment protocols, simulates future response activities. The PCMS works by simulating the movement of individual casualties through each step of the appropriate treatment protocol. If the protocol indicates that an ICU nurse and 2 doses of antidote are required, then those resources are identified and summed as part of the output report. The subsequent PCMS report lists resources required to provide optimal casualty care.

Figure 6-2 depicts the CBIRT architecture. CasFlow performs most of the necessary functions to provide the PCMS capability. The system normally works by accepting a casualty stream, each with a particular injury and simulating their treatment from the start of medical care (buddy aid) through evacuation to a hospital. Because CBIRT will invoke this prediction some time after an incident began, CasFlow has been modified to include the ability to pre-load it with casualties already in the different medical treatment facilities.

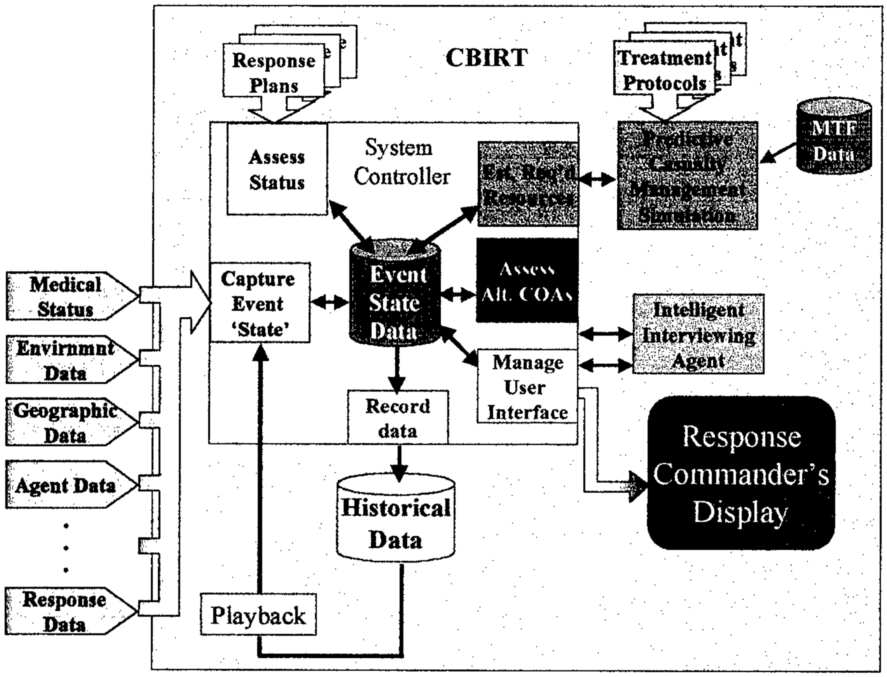


Figure 6-2 CBIRT Architecture

Nuclear, Biological, and Chemical Decision Support Tool for the US Army

The increasing threat of Nuclear, Biological, and Chemical (NBC) warfare and terrorism and the political uncertainties in our world today, require tools to help our military and civilian responders prepare for these possibilities.

The NBC Decision Support Tool (NBC DST) supports the US Army medical planning, and is currently being developed in cooperation with the Army Office of the Surgeon General to ensure that our armed forces are prepared for the special requirements of an NBC attack.

The NBC DST tool suite consists of three modules: the Casualty Estimator, the Resource Requirements Estimation, and the Course of Action Analysis. ScenPro has the primary responsibility for the definition and development of both the Resource Requirements Estimation and Course of Action Analysis modules.

The Casualty Estimator estimates the number of casualties expected based on a defined attack scenario. The scenario will include the population at risk, their locations in relation to the casualty source, and the attack NBC agent and method of delivery.

The Resource Requirements Estimation module calculates an estimate of the medical resources required and the output over time to decontaminate, triage, treat and transport the identified casualties.

The Course of Action Analysis (COAA) module allows the medical planner to compare medical resources required to care for the casualties, and directly compare those to the actual medical resources to be deployed in the field, called the medical Course of Action. Medical planners use the COAA module outputs to quickly visualize resource areas where the available resources in the field are estimated to be strained or insufficient. The planner can then develop, through "what if" analysis, the most effective medical Course of Action.

The following figure is an example of a Course of Action Analysis report.

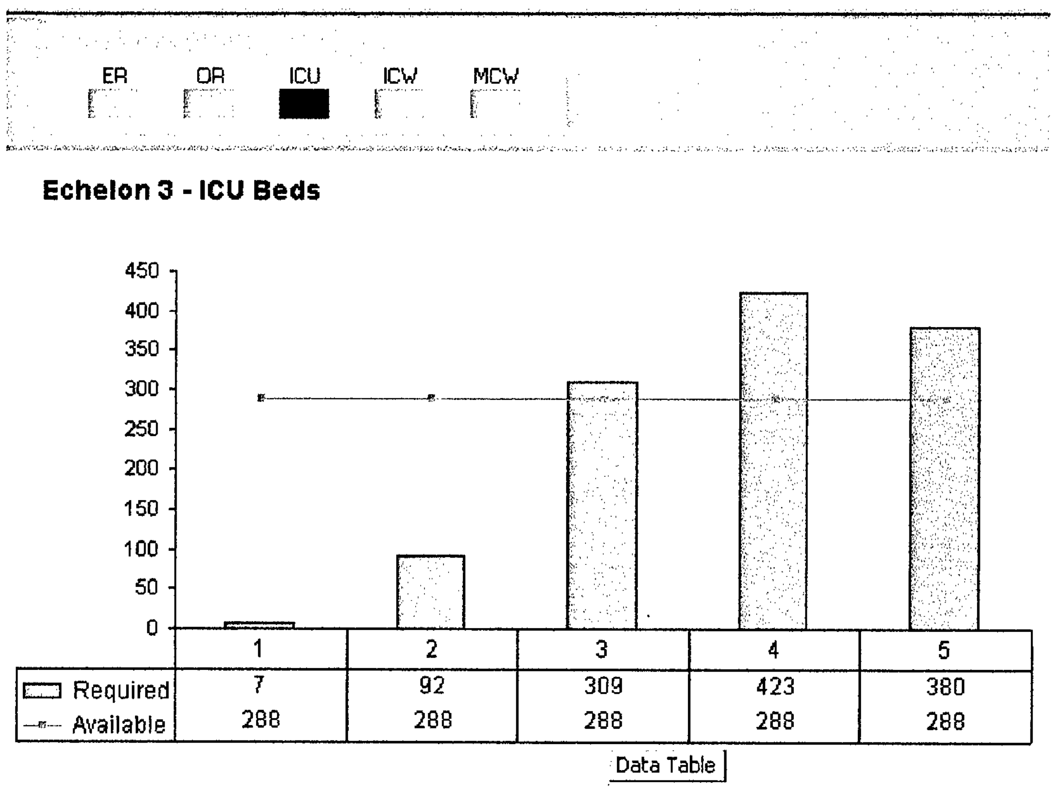


Figure 6-3 Sample NBC DST Course of Action Analysis Report

The knowledge gained from the development of CasFlow has been very instrumental in the design and implementation of the Course of Action Analysis module. CasFlow is considered to be the back-up technology for this module should the need arise.

The NBC Decision Support Tool prototype will be completed in June 2000.

7.0 Conclusions

Once an initial set of data was collected to run the simulation, the system was run on the proposed configuration of the LPD-17. The data included those laid out in Section 3.0 of this document.

The results of these tests were presented by Bill Pugh as outlined in Section 5.0, LPD-17 War Room. Subject Matter Experts reviewing our results indicated that they were believable and acceptable for the design of the ship's medical space.

CasFlow User's Manual

Appendix A

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

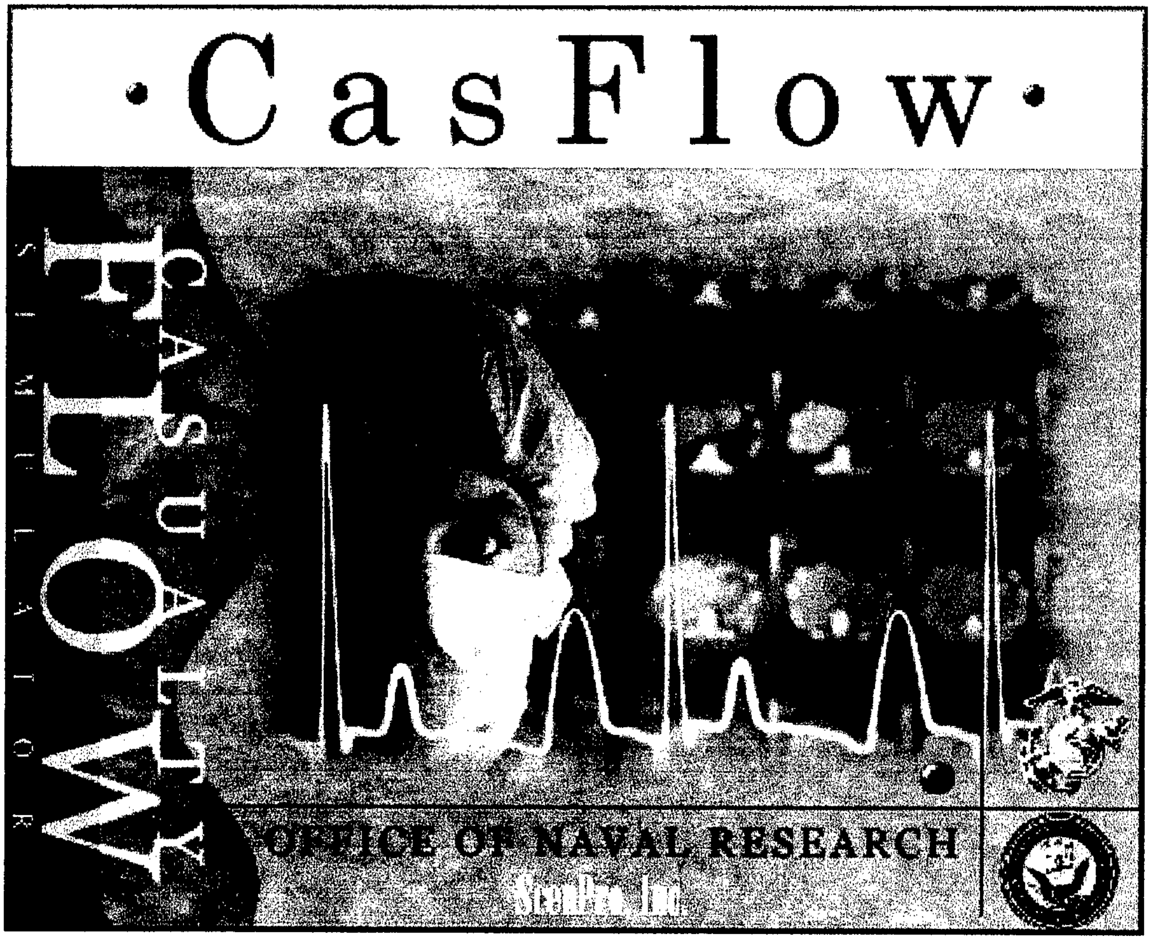
Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

CasFlow V3.0 User's Manual

Casualty Flow Analysis Tool
Operation and Installation Procedures



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Introduction

Effective shipboard medical care depends on having the proper resource mix for casualties as they flow through the system. Identifying the proper mix is complicated by its dependence on mission types. For example, the types and volume of casualties seen in peacekeeping operations are very different from wartime operations.

To address this problem ScenPro, Inc. developed a casualty flow analysis tool, CasFlow, under funding from the Office of Naval Research, contract number N00014-97-C-0317. CasFlow combines a discrete event simulator with Visio, Access, and Excel to enable medical planners to evaluate resource needs under user specified scenarios. CasFlow "moves" casualties through medical treatment facilities recording a wide variety of statistical information related to mortality, delays, staff use, and consumption of resources.

The movement profiles and resource consumption rates are based on treatment brief and materiel use databases developed by the DMSB/JRCAB. Ease of use is a major design consideration. Unlike most simulation systems, CasFlow users are not required to have simulation backgrounds or extensive computer experience.

Overview of CasFlow

The Casualty Flow Analysis Toolset consists of the following parts,

1. Visio-based Graphical User Interface
    - CasFlow.Exe – a project management dialog,
    - MTF Definition – a Visio file that allows users to graphically define a Medical treatment Facility,
    - Stream Definition – a Visio file that allows users to graphically define a casualty stream,
2. Databases
    - Task-Time-Treater Medical Database
    - CasFlow Database
3. CasFlow.dll - the casualty flow simulation engine, and
4. Casualty Analysis System - an Excel workbook for analyzing CasFlow's outputs.

Minimum System Requirements

Windows 95/98/NT, Microsoft Excel 95 or better, Visio 2000 (any edition) or better. While Microsoft Access is not required, having it allows direct viewing of the simulation output files. The simulation runs can generate considerable volumes of data for long evolutions. It is recommended that CasFlow be installed on systems with at least 100 MB of free hard disk space.

On May 10, 1999 the Department of the Navy announced that they had formed a new enterprise agreement with Visio Corp. The blanket purchase agreement holds for at least two years and covers the entire Visio product line. The agreement provides for significantly reduced purchase price of the Visio products. Microsoft bought Visio Corporation late in 1999.

In the event that Visio is not available on your computer, you can use the Wizard-based User Interface to create and run a scenario.

Installation

Insert the CasFlow V3.0 CD into the CD-ROM drive. Next, start the installation program from the Start Menu by clicking on [Start] then selecting [Run…]. This will bring up a small dialog box titled "Run." Enter the following text in the edit box in the dialog box:

X:\setup.exe

Please replace the X in the above command with the actual drive letter of the CD-ROM drive.

The installation program requires that you answer a short series of questions and then installs CasFlow onto the hard drive. The default directory to install CasFlow is C:\Program Files\ScenPro\CasFlowV3. This can be changed during installation.

Installed Files

The files associated with this program, where they will be loaded, and a short description of them follows:

- C:\Program Files\ScenPro\CasFlowV3\CasFlow.exe - This is the main program controlling CasFlow. It is a dialog box that allows the user to create or edit an MTF configuration, create or edit a casualty stream, to create or edit a scenario, and to start the simulation engine.

- C:\Program Files\ScenPro\CasFlowV3\MTF Definition.vst – This is a Visio template file that can be used to create or edit an MTF Configuration. When you open this file, it is immediately converted to a .vsd drawing file and you are required to enter a file name.

- C:\Program Files\ScenPro\CasFlowV3\Stream Definition.vst – This is a Visio template file that can be used to create or edit a casualty stream. When you open this file, it is immediately converted to a .vsd drawing file and you are required to enter a file name.

- C:\Program Files\ScenPro\CasFlowV3*.vss – This is a set of Visio stencils that contain the drag and drop shapes used to configure an MTF or casualty stream. There is no need to open these files directly, any .vst or .vsd file will load these into Visio automatically.

- C:\Program Files\ScenPro\CasFlowV3\CFWiz.exe - This is the secondary user interface for the simulation engine. It is a Wizard that collects all the information about the simulation that you want to run.

- C:\Program Files\ScenPro\CasFlowV3\cfengine.dll - This file contains the software that runs the simulation engine. It must be in the same directory as CasFlow.exe and CFWiz.exe.

- C:\Program Files\ScenPro\CasFlowV3\readme.doc.

- C:\Program Files\ScenPro\CasFlowV3\data\CasFlowData.mdb - This is the Access database that holds the MTF configurations, casualty streams, and the scenario descriptions.

- C:\Program Files\ScenPro\CasFlowV3\data\TTTDatabase.mdb - This is the Access database that holds the Task-Time-Treater files used by the simulation engine.

- C:\Program Files\ScenPro\CasFlowV3\data\CasFlowAnalysis.mdb - This is the Access database that holds all the data generated by the simulation engine. It can get quite big unless you delete some records out of it. See the section on clearing the database elsewhere in this manual.

- C:\Program Files\ScenPro\CasFlowV3\data\CasFlowAnalysis.xls - This is the Excel workbook that holds all the pivot tables and charts used to compare simulations. It also contains high level controls to aid in maintaining the database.

Running CasFlow

This section details the specific screens and options in the CasFlow Version 3.0 system.

Typical Usage Overview

Typical usage follows a 6-step procedure:

1. Start the Graphical User Interface, CasFlow.exe.

2. Create or Edit an MTF Configuration.

3. Create or Edit a Casualty Stream.

4. Create or Change a Scenario.

5. Run the simulation engine, which auto-loads the results into Access upon completion, and then starts the CasFlow Analysis Tool.

6. Examine the results of the simulation and compare / contrast the results to other simulation results.

If modifications to the current scenario are appropriate or other scenarios remain to be run, return to Step 1.

Startup

The first step in running the CasFlow simulation is to start the CasFlow interface program. The name of this program is **CASFLOW.EXE**. It can be found two ways. The first is by clicking on the [Start] menu, then selecting [Programs], then selecting CasFlowV3, and finally selecting CasFlow.exe.

The second way is to start the Windows Explorer and get to the directory

C:\Program Files\ScenPro\CasFlowV3

and double click on the file named **CASFLOW.EXE.** The following screen will appear:

CasFlow's interface can be found in the CasFlow directory (the default directory address is c:\Program Files\ScenPro\CasFlowV3). The name of the wizard interface program is CASFLOW.EXE.

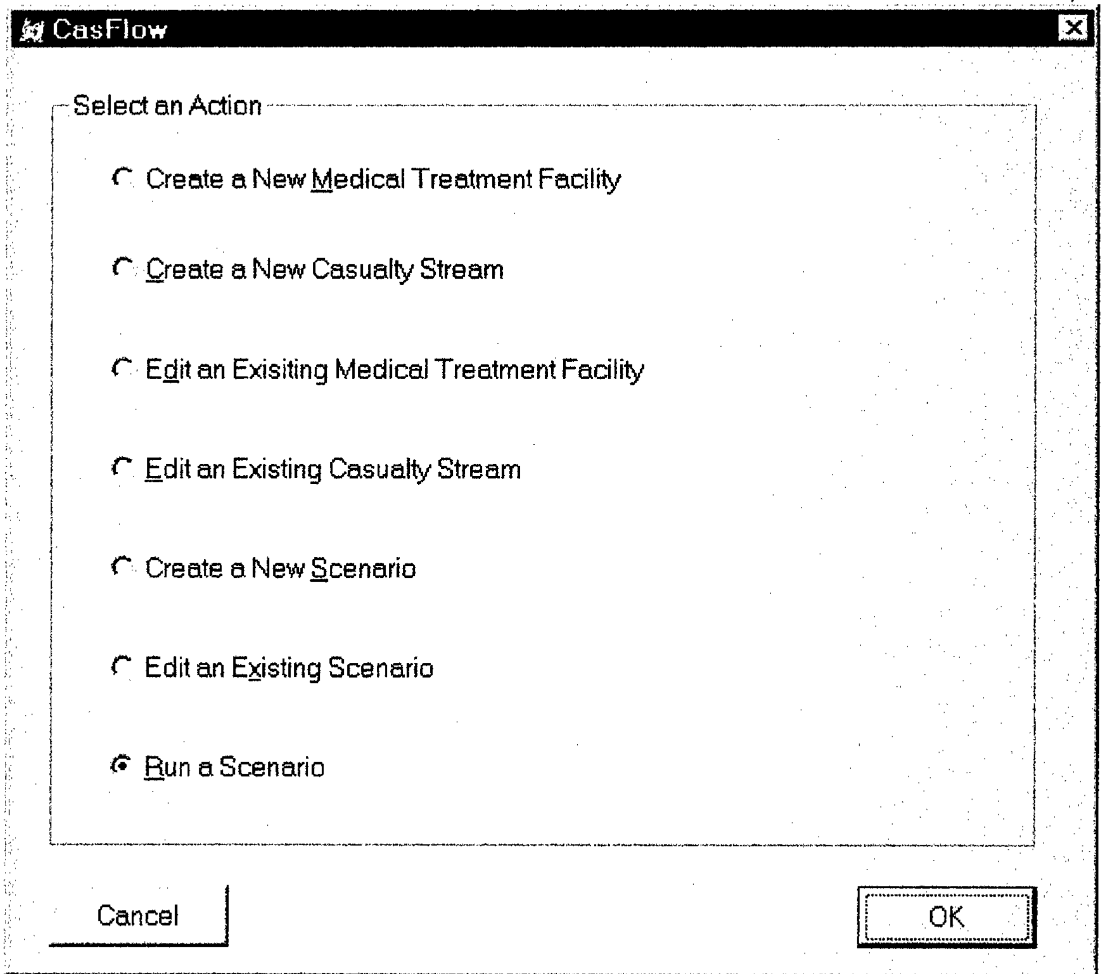
You can start the CasFlow Interface in any of the three ways common to Windows:

- Select the program from the Start menu. The default location is [Start | Programs | ScenPro | CasFlowV3 | CasFlow]

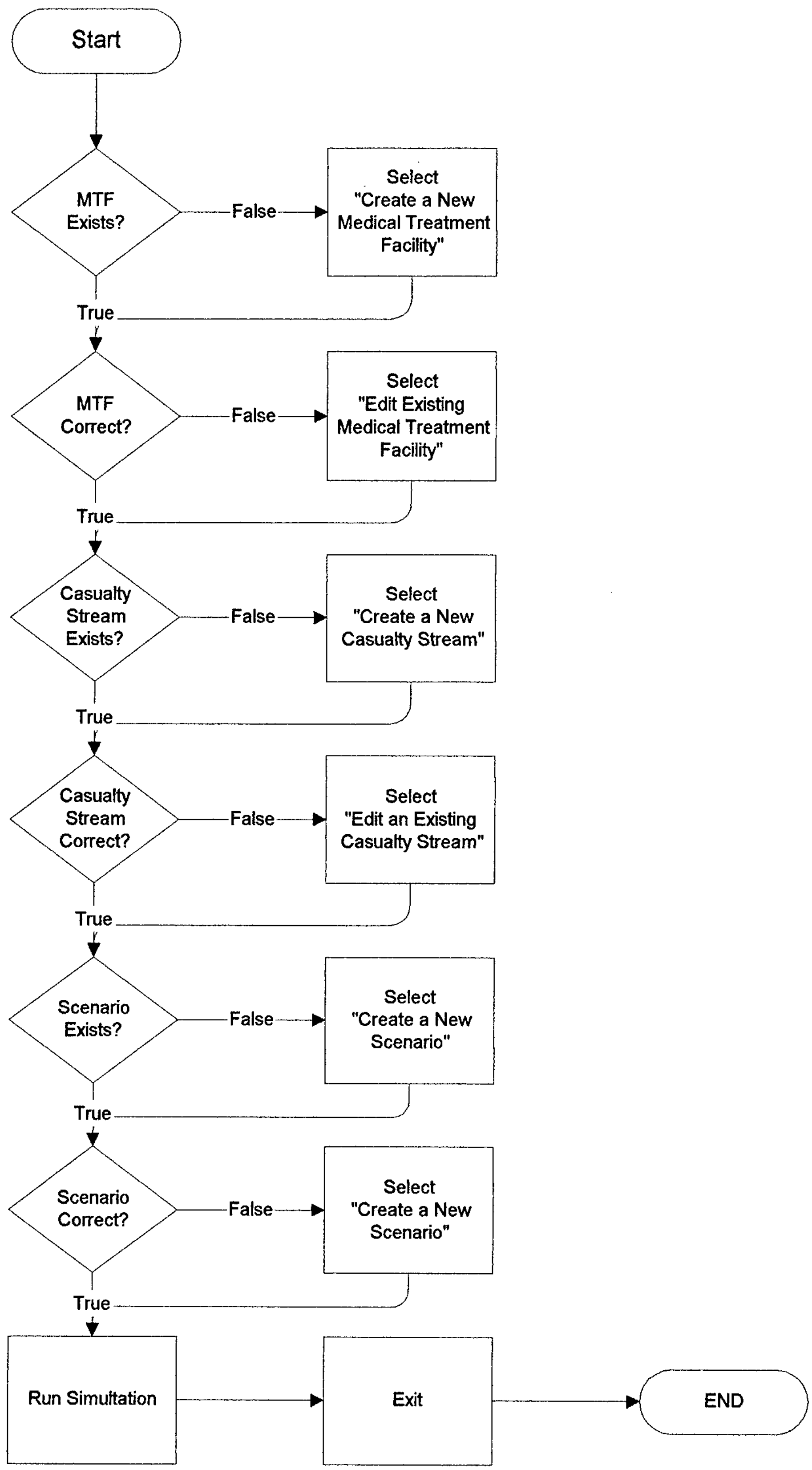
- Start the Windows Explorer, navigate to the CasFlowV3 directory, double-click the CASFLOW.EXE file. There are a number of ways to start the Windows Explorer. The simplest way is to RIGHT-CLICK on the Start menu button on the start menu. Click on the "Explorer" item in the pop-up menu. After the Windows Explorer starts, navigate to the CasFlowV3 directory. The default address for this directory is c:\Program Files\ScenPro\CasFlowV3. Within this directory, double-click on the CASFLOW.EXE file.

- Enter the address of the CasFlow Interface program in the Run Dialog box. Start the Run dialog box by selecting Run in the Start menu. Either directly enter the address or navigate to it. The default address is: c:\Program Files\ScenPro\CasFlowV3\CasFlow.exe

Once the CASFLOW.EXE program starts, the following dialog box is displayed. This dialog box is the primary control panel for CasFlow's Graphical User Interface.

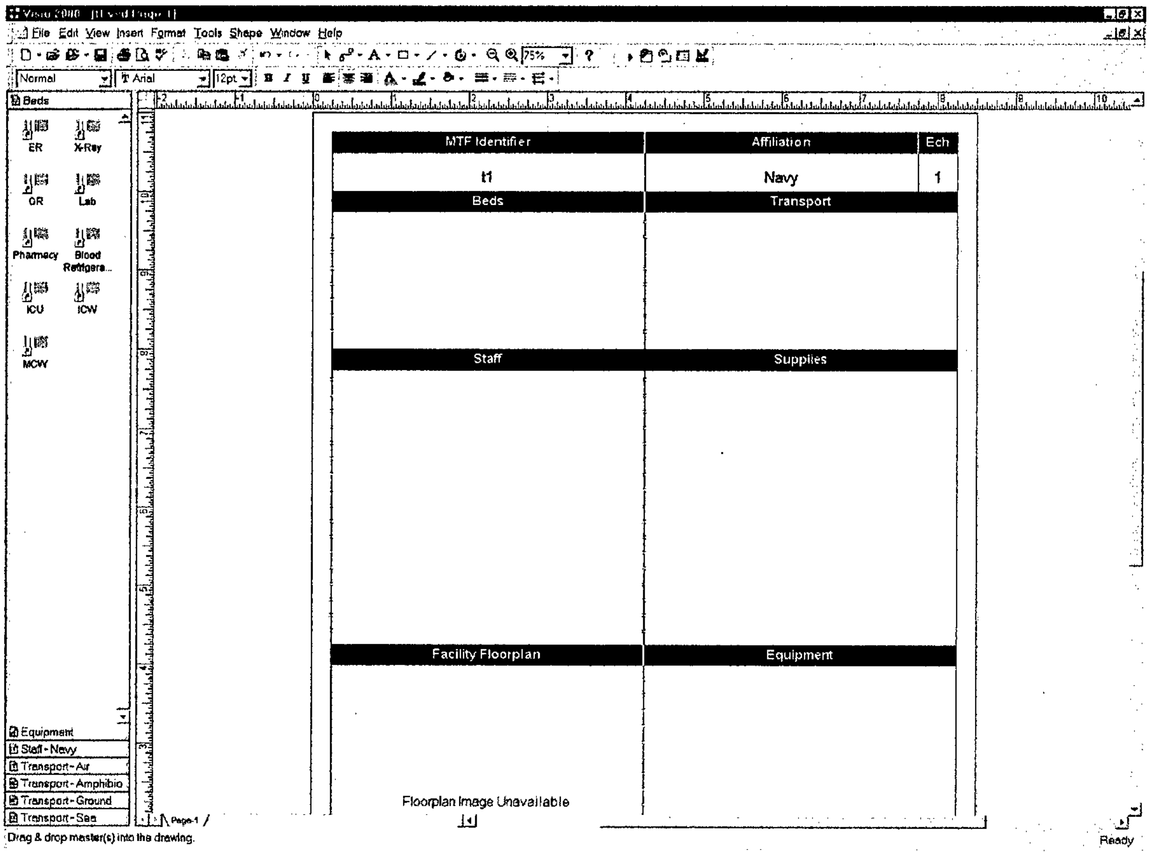


Use the following flow chart to select the action in the CasFlow Dialog:


Start
MTF Exists?
False
Select "Create a New Medical Treatment Facility"
True
MTF Correct?
False
Select "Edit Existing Medical Treatment Facility"
True
Casualty Stream Exists?
False
Select "Create a New Casualty Stream"
True
Casualty Stream Correct?
False
Select "Edit an Existing Casualty Stream"
True
Scenario Exists?
False
Select "Create a New Scenario"
True
Scenario Correct?
False
Select "Create a New Scenario"
True
Run Simultation
Exit
END

Creating or Editing a Medical Treatment Facility

A Medical Treatment Facility is graphically defined using a special Visio drawing. Selecting Create or Edit of an MTF will cause Visio to launch and display a page similar to the figure below:

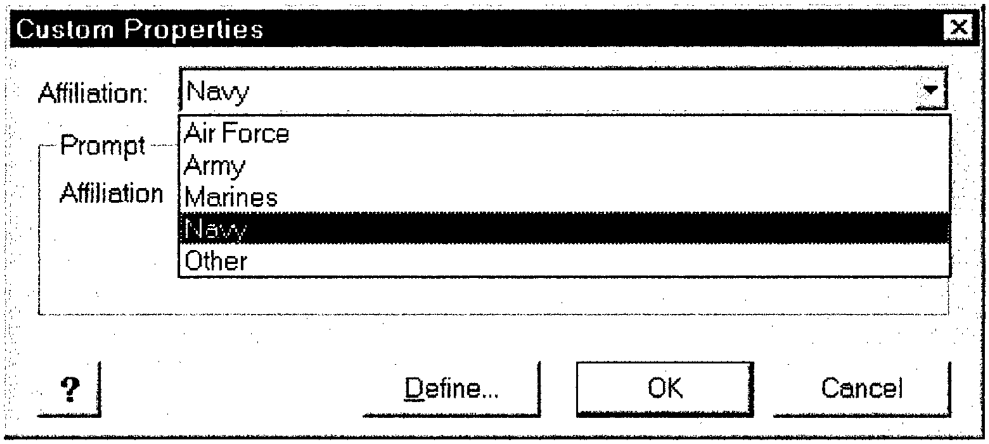


If this is a new MTF, the operator is required to save the drawing and select the CasFlow database associated with this MTF.

NOTE: The name of the MTF is the filename under which the Visio file is saved.

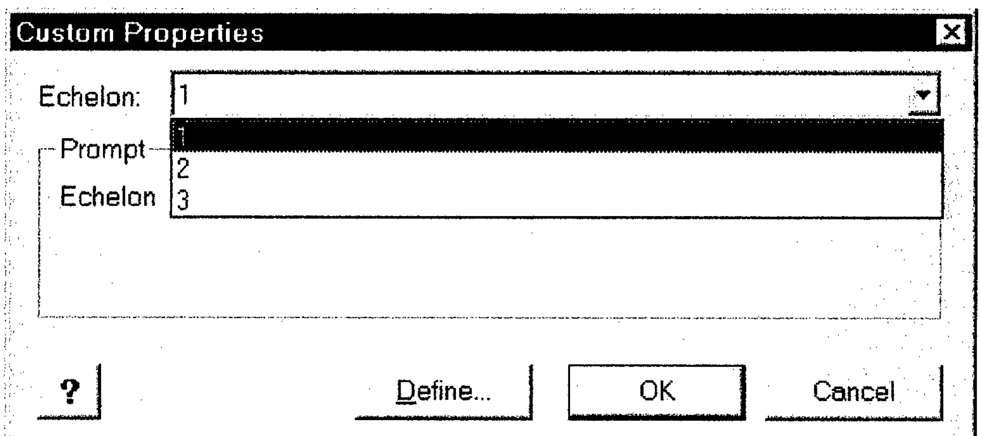
Selecting the Affiliation

The affiliation or service that this MTF serves is selected by double clicking the "Affiliation" area on the drawing, selecting the service in the list box, and selecting "OK":



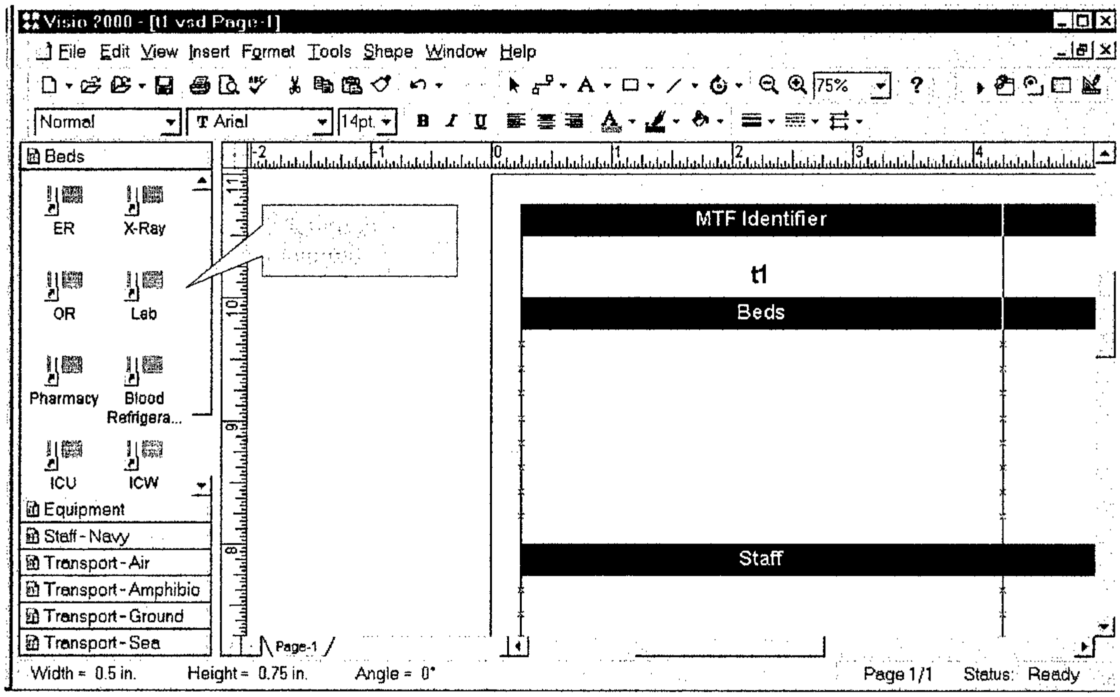
Selecting the Echelon

The echelon that this MTF serves is selected by double clicking the "Echelon" area on the drawing, selecting the echelon number from the list box, and selecting "OK":

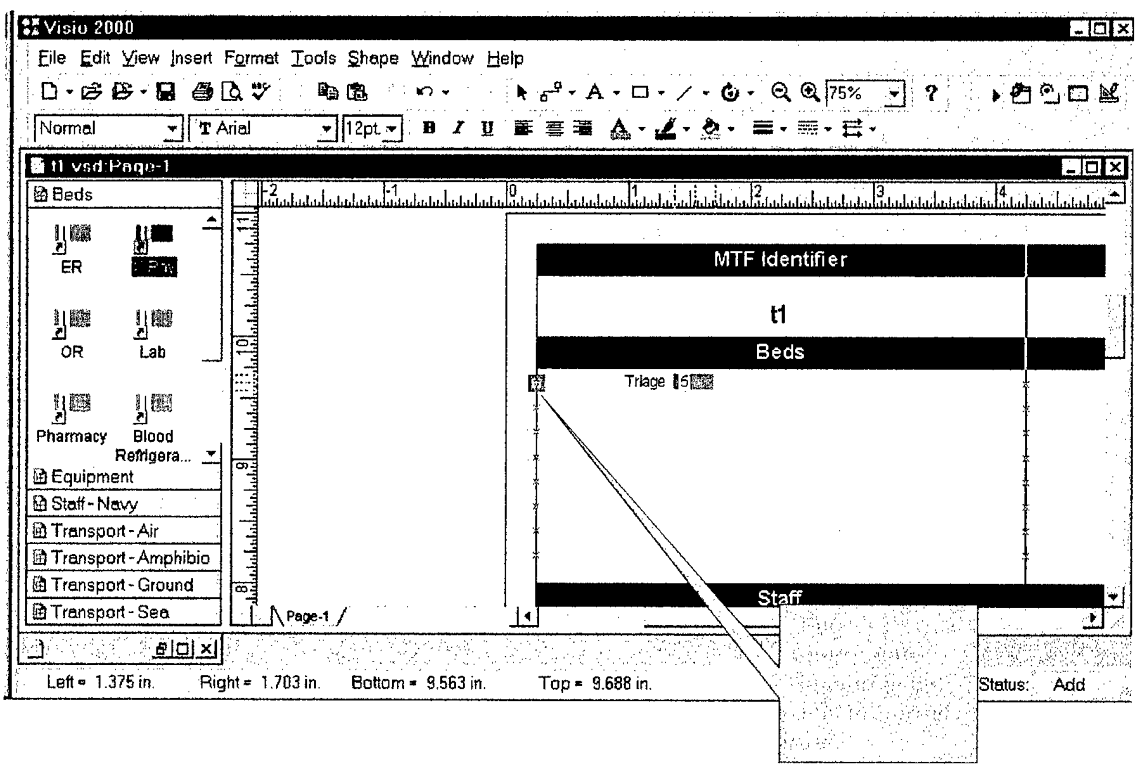


Adding Resources

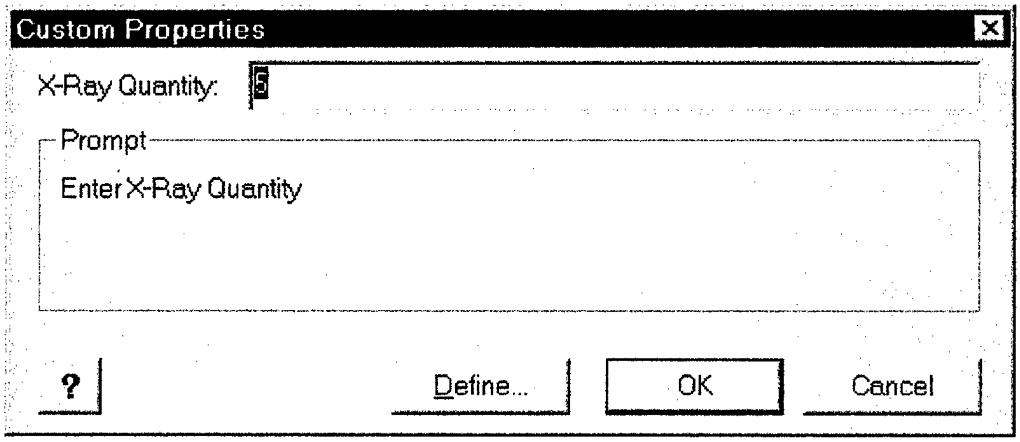
The resources (beds, staff, equipment, transports, and supplies) of an MTF are defined by dragging the proper resources from the palettes located on the left side of the drawing:



To add a new resource, drag the resource from the appropriate palette to the area on the page and connect the resource to one of the blue connection points:



A dialog box will appear asking for the quantity of the the resource available at this MTF:



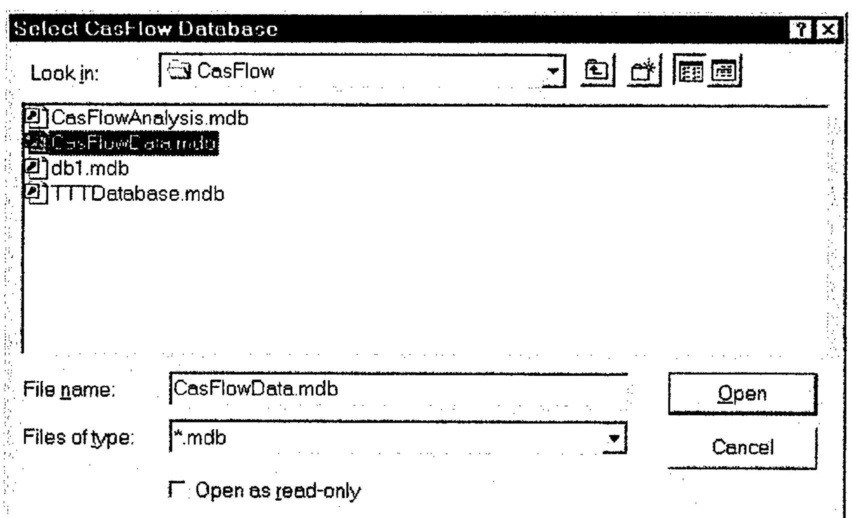
Enter the appropriate quantity and select "OK"

Note: You may connect the resource to any of the connection points. There is no need to connect the resource to the next open point.

Note: If a resource is dropped in the wrong area or not connected, it will automatically move to the center of its appropriate area. While it is not necessary to connect the resource to the area, connection will improve the readability of the document when printed.

Note: If there is insufficient space for additional resources, Select "Insert->Page" from the Visio Menus. A new page will be created with areas similar to the first page. Simply add additional resources to the new page.

If the database has not already been selected, the following dialog box will appear. Please choose the CasFlow database that is used to store MTFs: CasFlowData.mdb.



Saving the Data

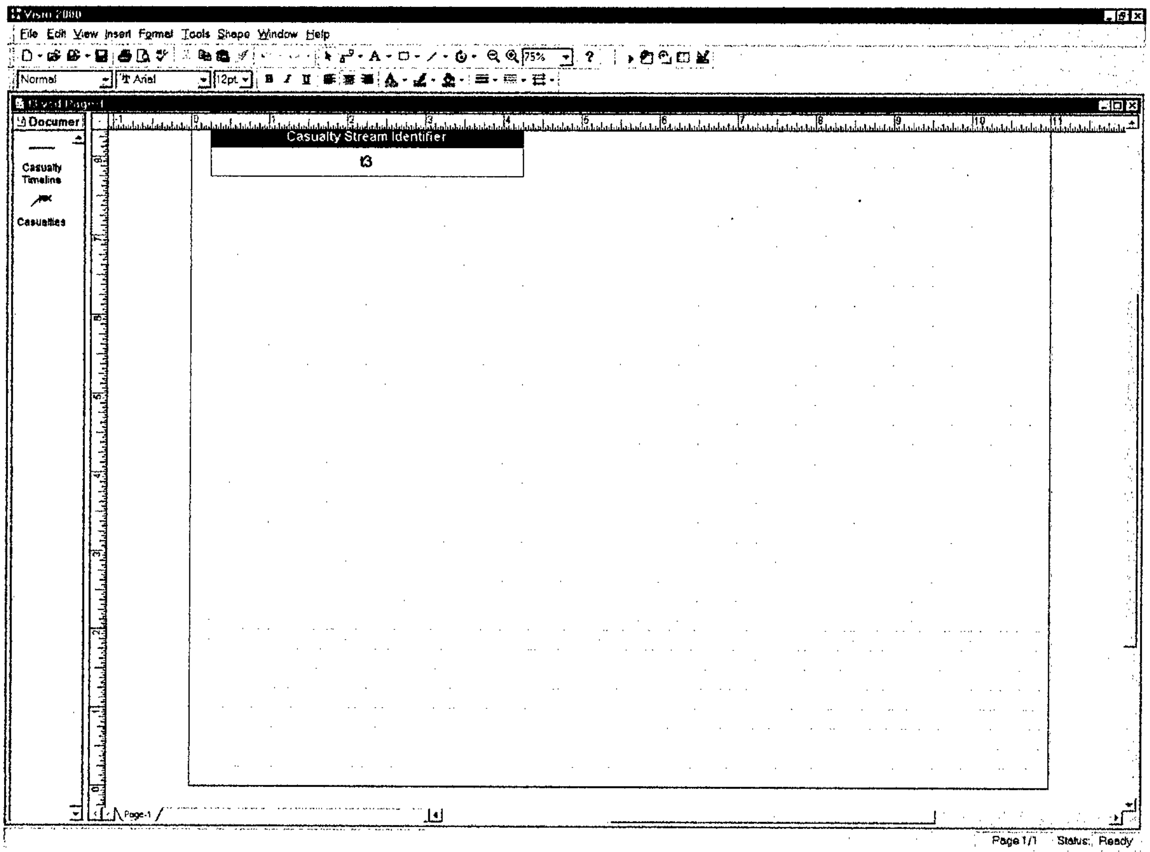
Saving the drawing will automatically update the CasFlow database with the definition of the MTF. To save the drawing, select "File->Save" from the Visio menu bar.

Note: If the CasFlow database cannot be found, a dialog requesting the operator to select the database will be displayed. Simply select the location of the database and select "OK". During installation, the database, named CasFlowData.mdb, is placed in the CasFlowV3 directory. If you cannot find it on your computer, you may want to re-install CasFlow.

Note: If the database does not exist, the drawing will be saved, but the data will not be committed to the database. Subsequent editing of the file will attempt to reconnect to the database.

Editing or Creating a Casualty Stream

A Casualty Stream is graphically defined using a special Visio drawing. Selecting Create or Edit a Casualty Stream will cause Visio to launch and display a page similar to the figure below:



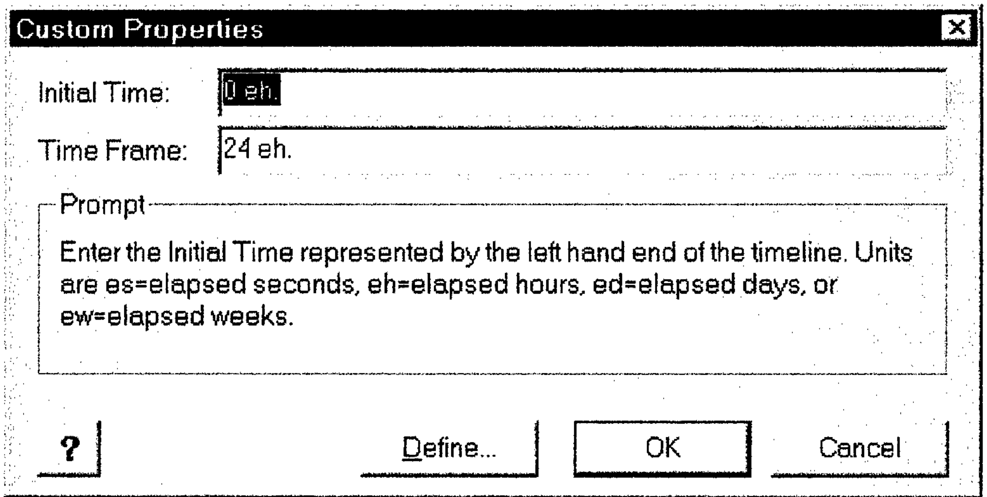
If this is a new stream, the operator is required to save the drawing and select the CasFlow database associated with this stream.

NOTE: The name of the Casualty Stream is the filename under which the Visio file is saved.

The casualty stream uses a timeline paradigm. One or more timelines are used to define the time over which the casualty stream is produced. Casualties (casualty shapes) are then connected to the timeline at the point in time that the casualty occurs. Two basic operations are employed in the casualty stream drawing: adding timelines and adding casualties.

Adding a Timeline

Drag the timeline shape from the palette on the left side of the screen and drop it on the page at an appropriate location (it can be moved later, if necessary). A dialog will appear allowing the operator to define the timeline as shown in the following figure.



The initial time is the point in time that the left end of the timeline represents. If more than one timeline is used, this value will normally be the value shown on the end of the previous timeline.

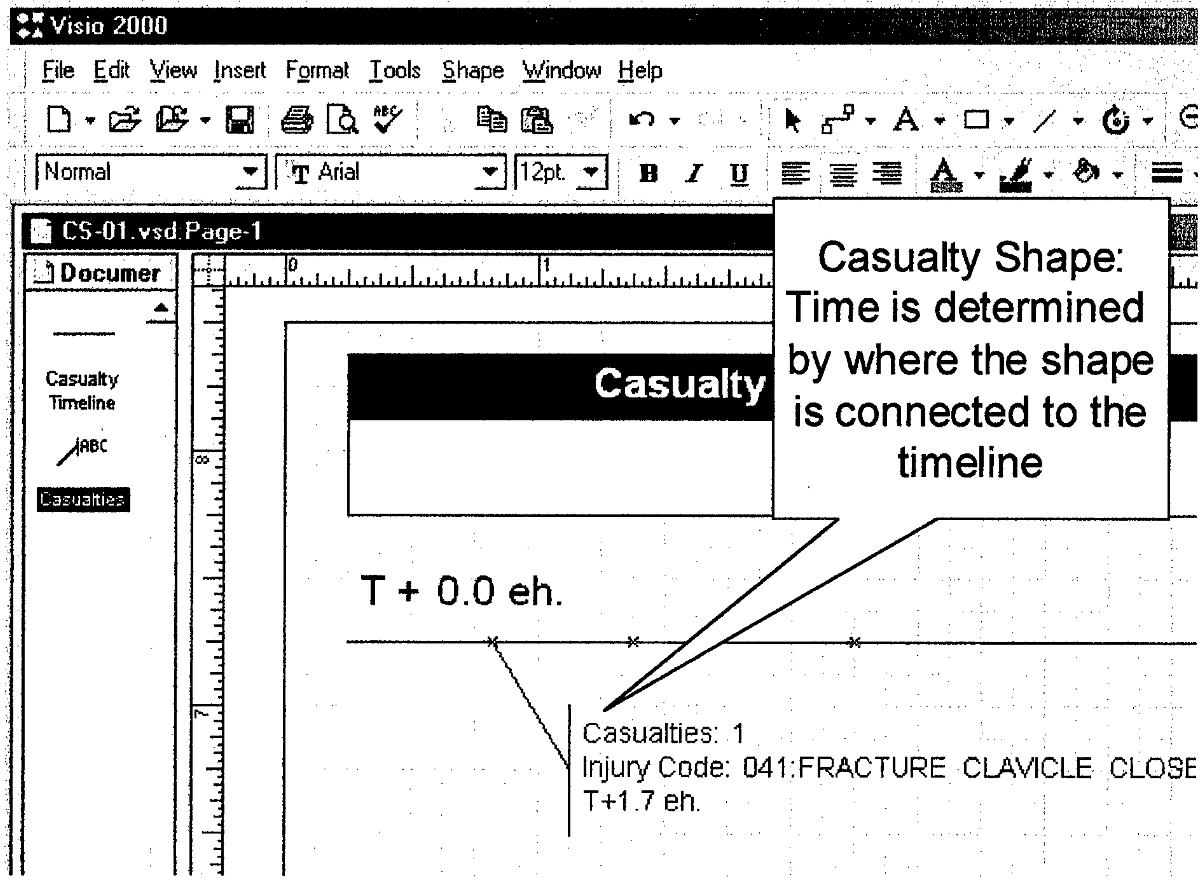
NOTE: Timelines can underlap or overlap. The time of the casualty is computed based on the definition of the attached timeline without regard to any other timelines on the page. Therefore, all timelines can represent any period of the event and need not be unique.

The time frame of the time line is the amount of time represented by the width of the line on the page.

The timeline can be positioned and sized anywhere on the page that is graphically pleasing. If additional room is needed for more timelines, simply select "Insert->Page" from the Visio menu. Add more timelines to additional pages as necessary.

Adding a Casualty

A casualty or a casualty group is defined by dragging and dropping a "Casualties" shape on the page. The time instant at which the casualty occurs is determined by where the casualty shape is connected on the time line. The time value is automatically calculated and displayed in the text associated with a casualty as shown in the following figure.



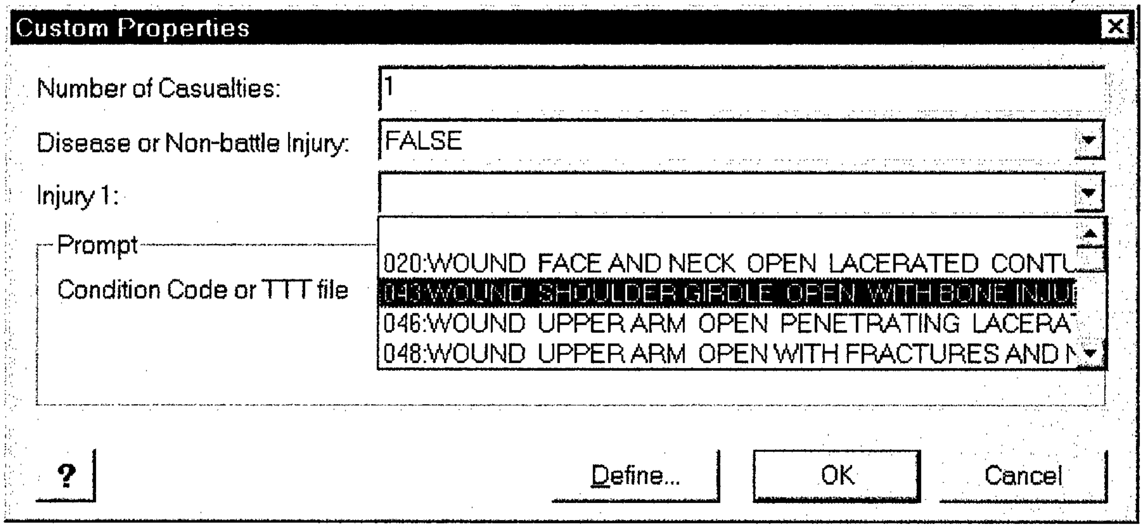
When a "Casualties" shape is dropped on the timeline, a dialog box appears asking the user to describe the casualty or casualties. The three values requested are:

- Number of Casualties:
- Disease or Non-battle Injury:
- Injury:

The Number of Casualties field can hold any integer from 1 to 32565. This feature allows the user to add casualty groups – such as might happen in a mass casualty situation. If, for example, there are 7 soldiers that have burns, then all 7 casualties could be added with one casualty shape by putting a 7 in the Number of Casualties field.

The Disease or Non-battle Injury field is a Boolean field asking if the injury is either a disease or other non-battle injury – in other words, a non-combat injury. Select the appropriate value, True or False.

The Injury field asks which injury the casualty or group of casualties has. The numbers and descriptions originated with the DEPMEDs work. Of the original 300 conditions, the list in this dialog box is limited to those for which a complete set of resources is available.



Any number of casualties can be added to the timelines. If there is insufficient room, add another page, add additional timelines, and continue adding casualties.

The casualty definitions can be edited by double clicking on the casualty shape (which will display the above dialog).

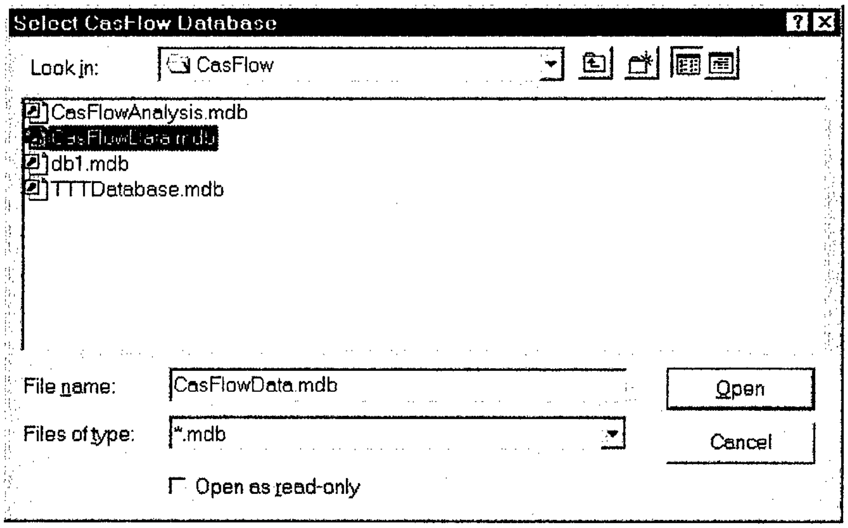
Saving the Data

Saving the drawing will automatically update the CasFlow database with the definition of the casualty stream. To save the drawing, select "File->Save" from the Visio menu bar.

Note: If the CasFlow database cannot be found, a dialog requesting the operator to select the database will be displayed. Simply select the location of the database and select "OK". During installation, the database, named CasFlowData.mdb, is placed in the CasFlowV3 directory. If you cannot find it on your computer, you may want to re-install CasFlow.

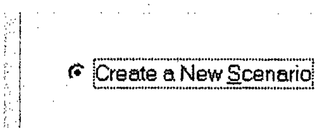
Note: If the database does not exist, the drawing will be saved, but the data will not be committed to the database. Subsequent editing of the file will attempt to reconnect to the database.

If the database has not already been selected, the following dialog box will appear. Please choose the CasFlow database that is used to store Casualty Streams: CasFlowData.mdb.

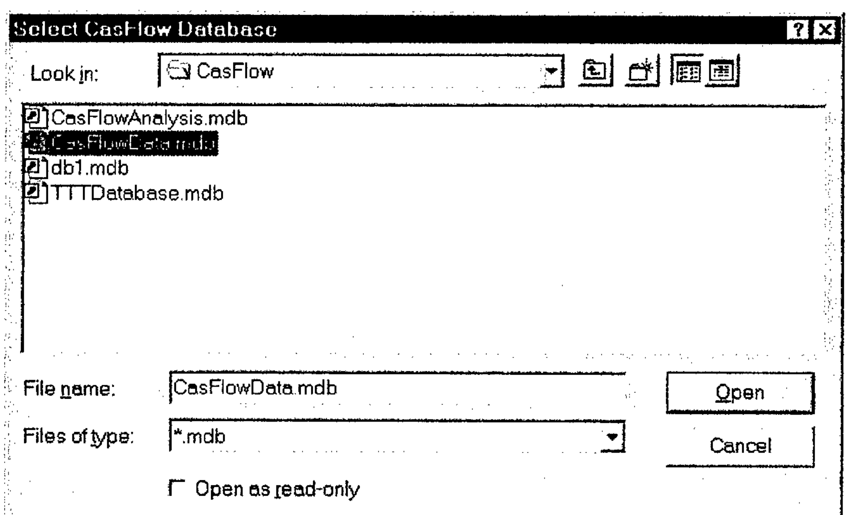


Creating a Scenario

A scenario defines a combination of a MTF and a casualty stream to the simulation engine. To create a new scenario, select the appropriate option in the CasFlow dialog:

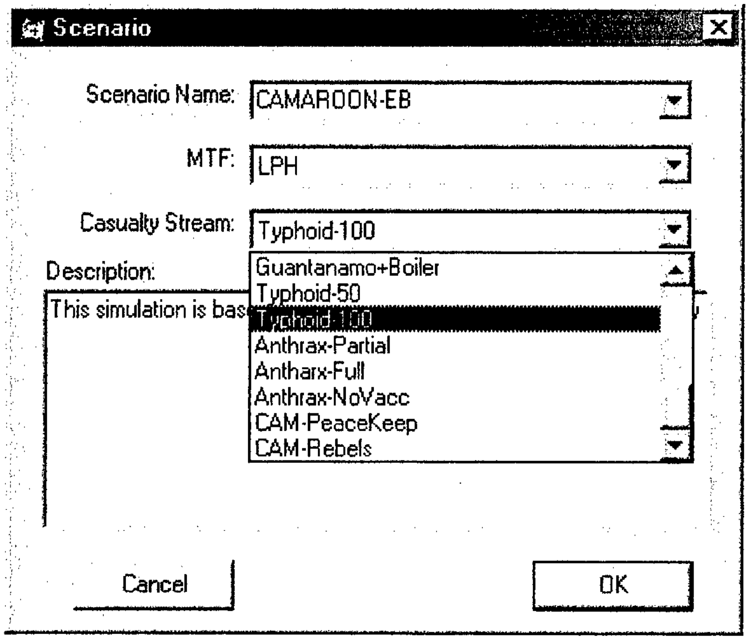


If the database has not already been selected, the following dialog box will appear. Please choose the CasFlow database that is used to store Scenarios: CasFlowData.mdb.



To define a scenario, the Scenario dialog box is used. A scenario is the joining (and naming) of a medical treatment facility and a casualty stream. If the scenario is run, the simulation engine will simulate the flow of the selected casualty stream through the selected MTF. There are four fields available to define a scenarios: the name, the MTF, the casualty stream, and an optional description field.

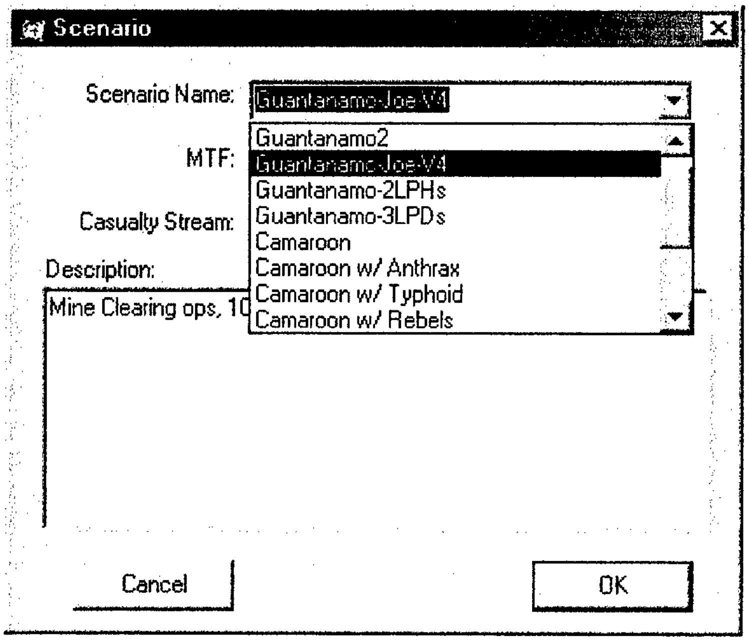
Create a name for the Scenario by typing into the “Scenario Name” field. Select the MTF and Casualty Stream for this scenario by selecting the appropriate names from the list boxes. Finally, a textual description of the scenario can be added in the “Description” field as shown in the following figure.



Select “OK” to save the scenario to the database or “Cancel” to discard the scenario.

Editing a Scenario

A scenario is edited just as it is created (see previous section) except that the name cannot be changed. Select the scenario from the “Scenario Name” list box. The MTF or casualty stream can be changed along with the description text as shown in the following figure.

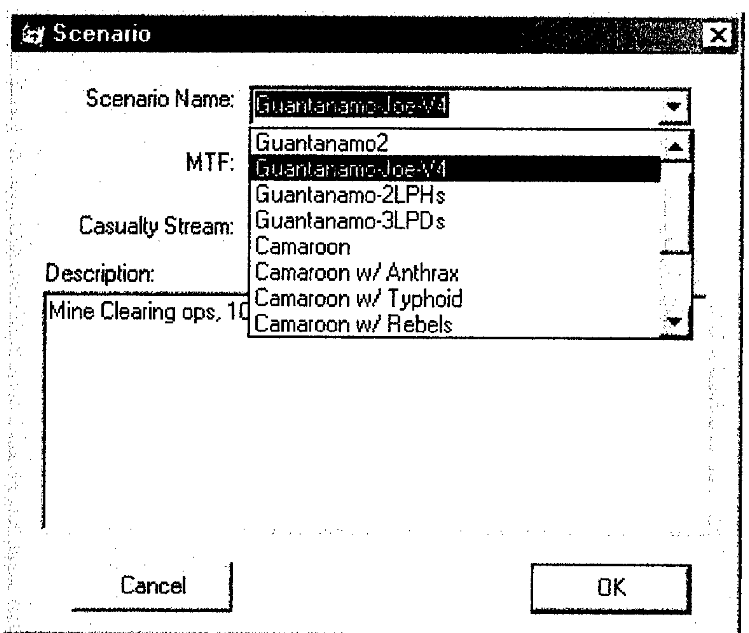


Select "OK" to save changes to the scenario to the database or "Cancel" to discard the changes.

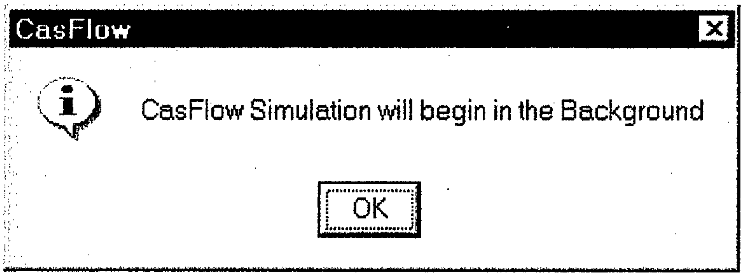
Simulation

Prior to running a simulation, please make sure Excel is not running.

To run a simulation, select "Run a Scenario" option and select the Scenario from the "Scenario Name" list box. In this dialog box, the MTF, casualty stream, and description cannot be edited.



Select "OK" to run the selected scenario or "Cancel" to abort the simulation. A confirmation of the simulation run will appear:



Select "OK".

The CasFlow simulation engine will then run the selected scenario in the background. This simulation will read in the scenario definition, set up the MTF, and "move" the casualties through the facility.

When the simulation is complete, the CasFlow Analysis Tool Excel worksheet will automatically start.

The CasFlow dialog box can be discarded by clicking on the Exit button at the bottom.

Results Analysis

Analysis is performed using a customized version of Microsoft Excel, called CasFlow Analysis. The CasFlow User Interface will automatically load the Access database and launch Excel when the simulation run is complete.

When the CasFlow Analysis workbook opens, you are presented with a worksheet that has a summary of all the scenarios loaded into the database along with numerous other worksheets. The additional worksheets contain various analytical computations. A wide variety of analyses are available and most are constructed using pivot tables,[1] providing even more analytical flexibility.

Note that if you want to make another simulation run, be sure to close Excel. This will ensure that the simulation database is available for the additional data and that Excel is properly synchronized.

An additional benefit of using Excel is its inherent support for user-defined metrics. Additional worksheets can be added, metrics defined, and charts created using simple links back to summary worksheets in the CasFlowAnalysis workbook.

Deleting a Scenario

At some point you will want to delete some scenarios to reclaim disk space. There are two steps to this. First, on the Excel menu bar select [CasFlow | Database... | Delete Scenario]. Select the scenario you wish

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[1] It is beyond the scope of this document to address the power of pivot tables. Virtually all Excel references, including the Microsoft supplied documentation, describe pivot tables and their use.

to delete and click on the Delete button. After deleting all the scenarios desired, click on Exit. To reclaim the disk space return to the Excel menu bar and select [CasFlow | Database… | Compact Database].[2]

CasFlow Demo

1. Start CasFlow by starting the program called CasFlow.exe.
2. Click on Create a New Scenario.
    1. Name your scenario. For example, enter "My First Scenario."
    2. Select the MTF. For example, select LPD-17.
    3. Select the Casualty Stream. For example, select Guantanamo Mine Clearing.
    4. Click OK
3. Click on Run Scenario
    1. Select the Scenario you just created. For example, select "My First Scenario."
    2. Click OK
4. Wait until Excel starts and finishes loading the data.
5. Walk through each of the worksheets showing how the slightly different scenarios (slightly less staff) produce different results.
6. Make sure that you close Excel before starting another simulation. Before closing Excel, make sure you save the workbook in order to retain the changes the last scenario made to the pivot tables.
7. Additional scenarios can be run and compared.

Wizard User Interface

CasFlow is delivered with a second user interface. This second interface utilizes the Microsoft wizard technique for interacting with the user. That is, it is a single dialog box composed of a number of pages connected with Back and Next buttons. This interface is important if your computer does not currently have Visio 2000 (or better) installed on it.

CasFlow's Wizard interface can be found in the CasFlow directory (the default directory address is c:\Program Files\ScenPro\CasFlowV3). The name of the wizard interface program is CFWIZ.EXE.

You can start the CasFlow Wizard User Interface in any of the three ways common to Windows:

[2] Note the other options under CasFlow on the Excel menu bar are for advanced use and technical support. It is not recommended you select them.

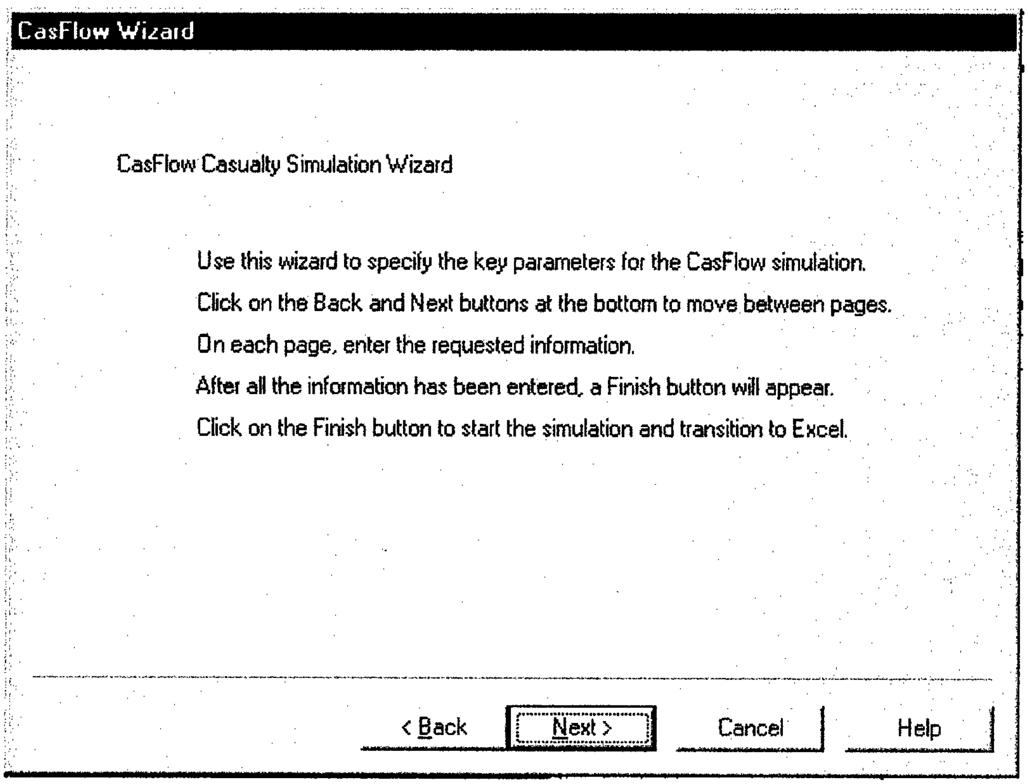
- Select the program from the Start menu. The default location is [Start | Programs | ScenPro | CasFlow | CasFlow Wizard]

- Start the Windows Explorer, navigate to the CasFlowV3 directory, double-click the CFWIZ.EXE file. There are a number of ways to start the Windows Explorer. The simplest way is to RIGHT-CLICK on the Start menu button on the start menu. Click on the "Explorer" item in the pop-up menu. After the Windows Explorer starts, navigate to the CasFlowV3 directory. The default address for this directory is c:\Program Files\ScenPro\CasFlowV3. Within this directory, double-click on the CFWIZ.EXE file.

- Enter the address of the CasFlow Wizard User Interface program in the Run Dialog box. Start the Run dialog box by selecting Run in the Start menu. Either directly enter the address or navigate to it. The default address is: c:\Program Files\ScenPro\CasFlowV3\CFWiz.exe

Startup

When the CasFlow Wizard Interface starts it displays the first of seven screens. To proceed to the next screen, click [Next >].



Scenario Selection

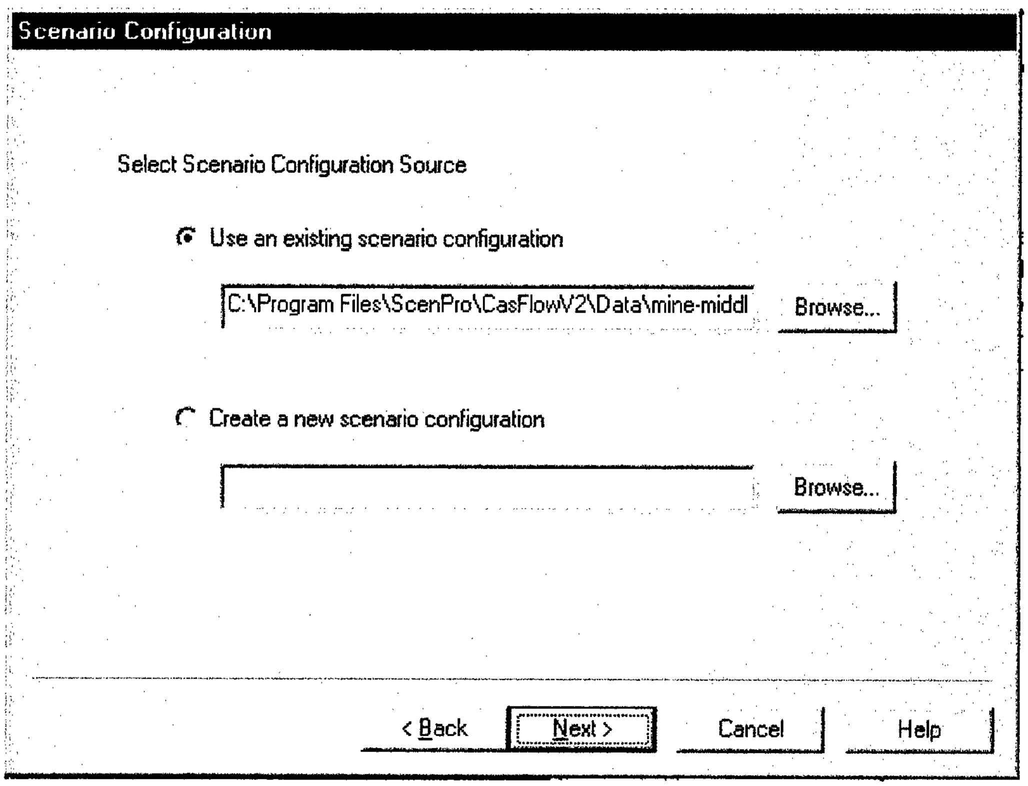
The second step is to select a scenario configuration source. The typical action is to click the upper radio button, "Use an existing scenario configuration."

Then click the [Browse…] button and locate one of the scenarios installed with the software. As an example,

C:\Program Files\ScenPro\CasFlowV3\Data\mine-middle-typical.ini

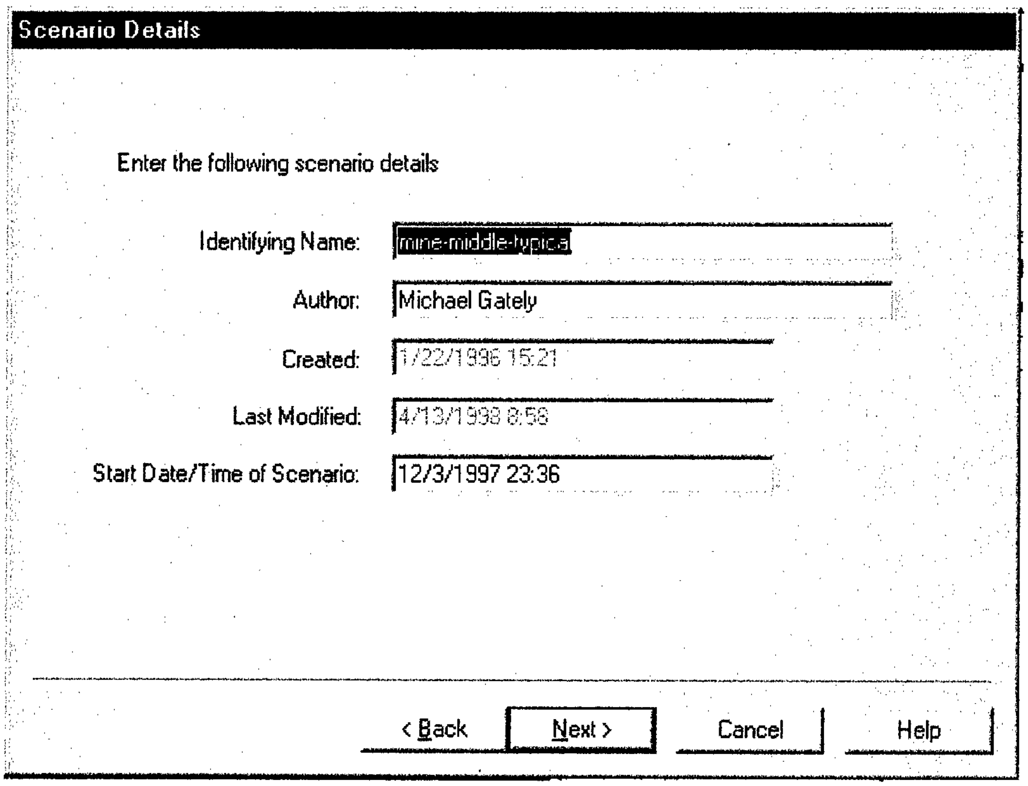
This scenario configuration uses a medium sized LPD-17 (7 Triage Room beds, 2 Exam Rooms, 2 ORs, 1 XRay, 7 ICU Beds, and 17 Ward Beds). The configuration uses a typical complement of doctors, which includes 2 doctors (1 on 1st shift), 2 nurses (1 on 1st shift), 6 corpsmen (3 on 1st shift), 1 anesthesiologist (1st shift), and 1 radiologist (1st shift).

It is also possible to define a new configuration file. The easiest approach is to select an existing configuration file, click the [Next >] button, then click the [< Back] button. Then select the "Create a new scenario configuration" radio button and enter a new filename. This will fill in the rest of the wizard screens with basic configuration information.



Summary Information Entry

The third step is to enter summary information about the scenario. This includes an identifying name (originally taken from the scenario configuration filename), the author, and the date and time the scenario begins.



Casualty Stream Selection

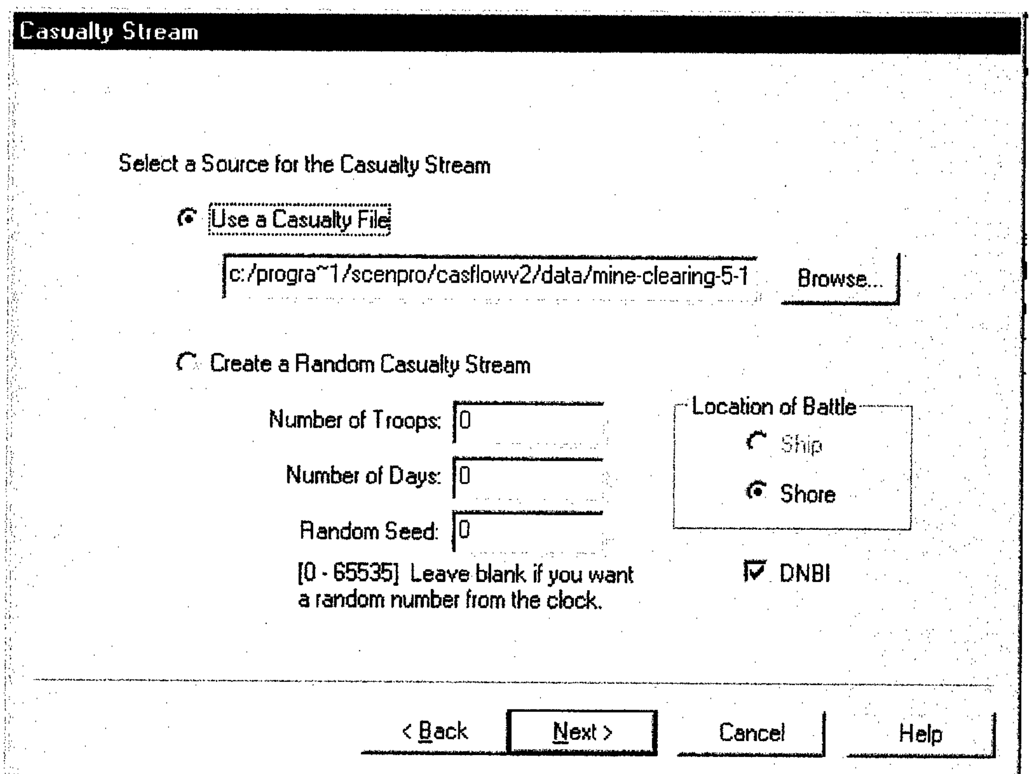
The fourth step is to specify the casualty stream. There are two approaches. The first is to indicate a file that already contains a casualty stream and the second is to allow the wizard to create a randomized casualty stream.

A casualty stream is a text file with the extension .CAS. Each line in the file represents a single casualty. There are four data items on each line:

- Time patient was injured (in minutes from start of simulation)
- Where patient was injured (-1 = battle front, 0 = DNBI on LPD-17)
- Number of injuries (currently always 1)
- Patient Condition

There are several casualty files installed with CasFlowV3. They are:

- Mine-clearing-5-11.cas – this file represents a scenario where the LPD17 is involved in an OCONUS mine clearing operation. This is a snapshot of the injuries that occurred on a particular day of that operation. At 8:00am, 5 DNBI casualties show up at the medical treatment facility. Later, at 9:35am, four soldiers are driving in a jeep to the mine clearing site and run over a live mine. There are a variety of injuries. Finally, just after noon, a soldier steps on a mine and a group of soldiers sustain injuries.
- 4days.cas – this casualty file is four repeating days of DNBI and battle injuries.
- 10days-10k-DNBI.cas – the automatic casualty generator created this file. It represents a typical set of injuries sustained by 10,000 soldiers over a 10-day conflict and includes DNBI.



Medical Treatment Facility Selection

There are three actions possible on this screen.[3] The first is to change the bottleneck algorithm. This is the algorithm that defines how to choose which casualty receives treatment next when a bottle neck has occurred. The bottleneck algorithm choices are:

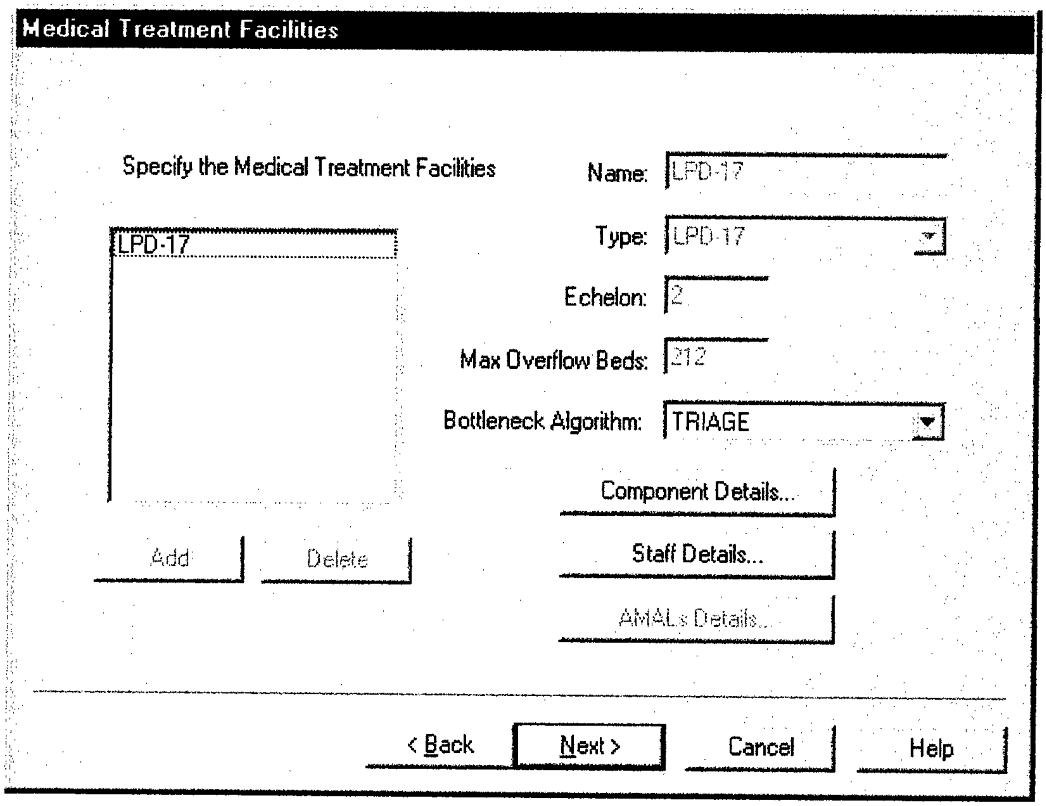
- TRIAGE – This algorithm begins by selecting the casualties with the highest triage category. Among these, it selects whoever has been waiting the longest.
- FIFO (First In, First Out) – This algorithm selects whoever arrived first.
- SHORT (Shortest Job First) – This algorithm selects the casualty whose next treatment step is the shortest.

Of these, the TRIAGE algorithm is the bottleneck algorithm of choice.

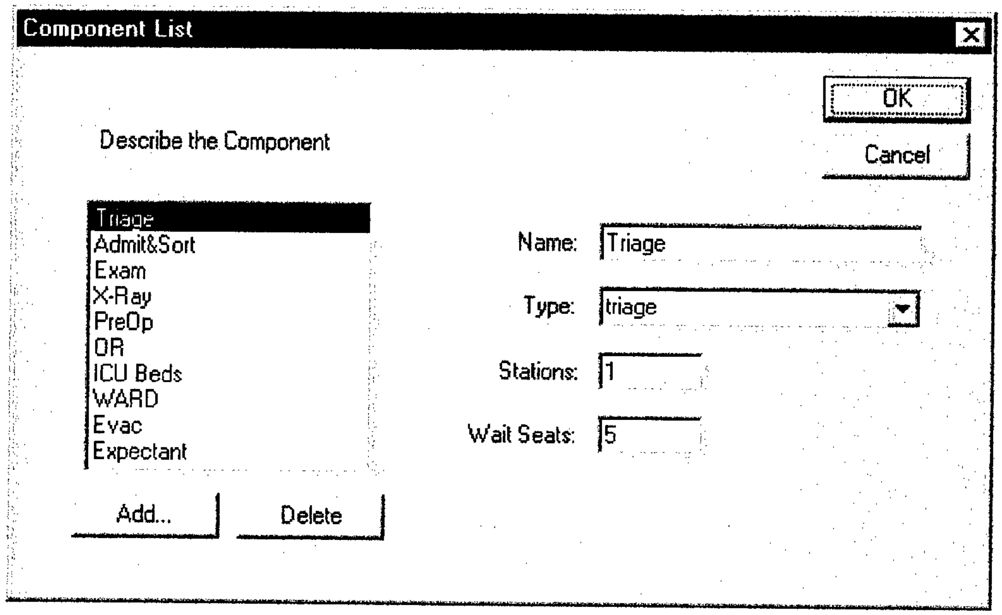
The second possible action is to click on the [Component Details…] button. This will bring up the Component List Dialog Box, which allows you to change the details of the medical treatment facility. See the *Component List Dialog Box* section for details.

Finally, you can click the [Staff Details…] button to bring up the Staff Dialog Box. This is where the details of the staff available for the MTF are held. See the *Staff Dialog Box* section for more information.

[3] The choices on this screen are limited at this time. CasFlow V3 was specifically targeted for the LPD-17 MTF.


Medical Treatment Facilities
Specify the Medical Treatment Facilities
LPD-17
Add
Delete
Name:
LPD-17
Type:
LPD-17
Echelon:
2
Max Overflow Beds:
212
Bottleneck Algorithm:
TRIAGE
Component Details...
Staff Details...
AMALs Details...
< Back
Next >
Cancel
Help

Component List Dialog Box



The *Component List Dialog Box* allows you to change the details of the components in the MTF.

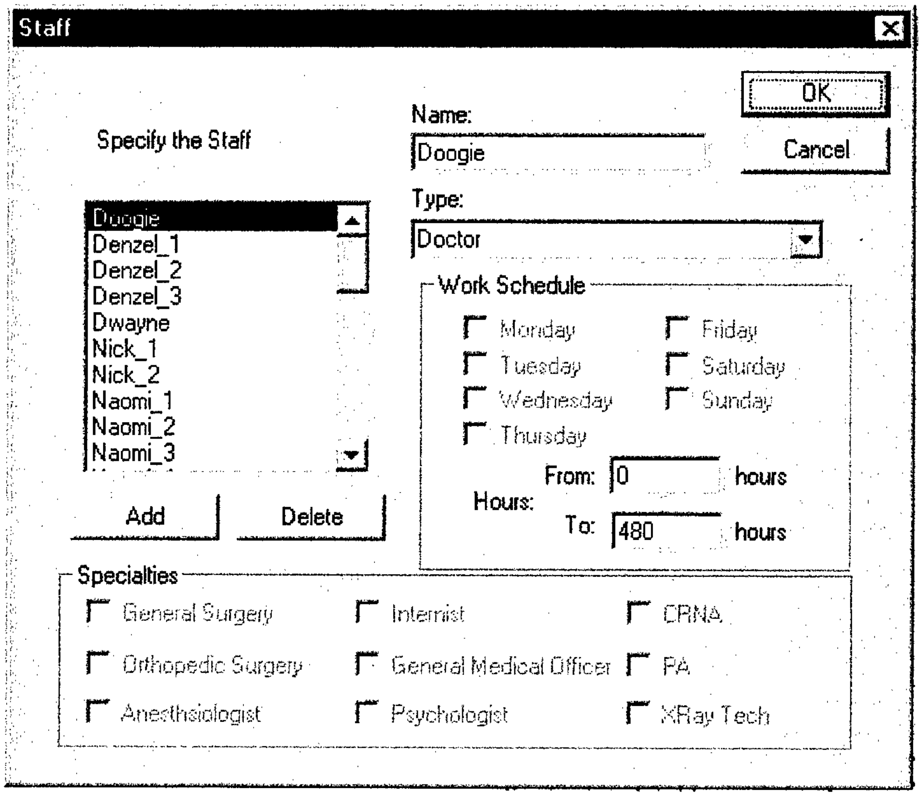
To modify a component in an MTF, begin by selecting it. Its Name, Type, number of Stations and number of Waiting "Seats" can then be changed. The Type of component is used by the treatment profiles and indicates the type of tasks performed in the component. The number of Stations designates the number of casualties that could be handled in parallel without considering staff or supplies. For example in a Ward the number of stations is the number of beds. In an XRay area the number of stations is the number of XRay machines.

To add component click the Add… button and edit the fields as desired.

To delete a component, select it and then click the Delete button.

Staff Dialog Box

The *Staff Dialog Box* allows you to change the details of the staff working in the MTF.



To modify the staff begin by selecting a staff member. This version of CasFlow supports changing the staff persons name, Type and Work Schedule. Note the From and To (Start and Stop) times for their work must be specified in minutes after midnight. That is, a shift from 0800 to 1700 would be From 480 To 1020.

To add someone to the staff, click on the Add button and fill out the Name, Type and Work Schedule fields.

To delete a staff member, select them in the staff list and click on the Delete button.

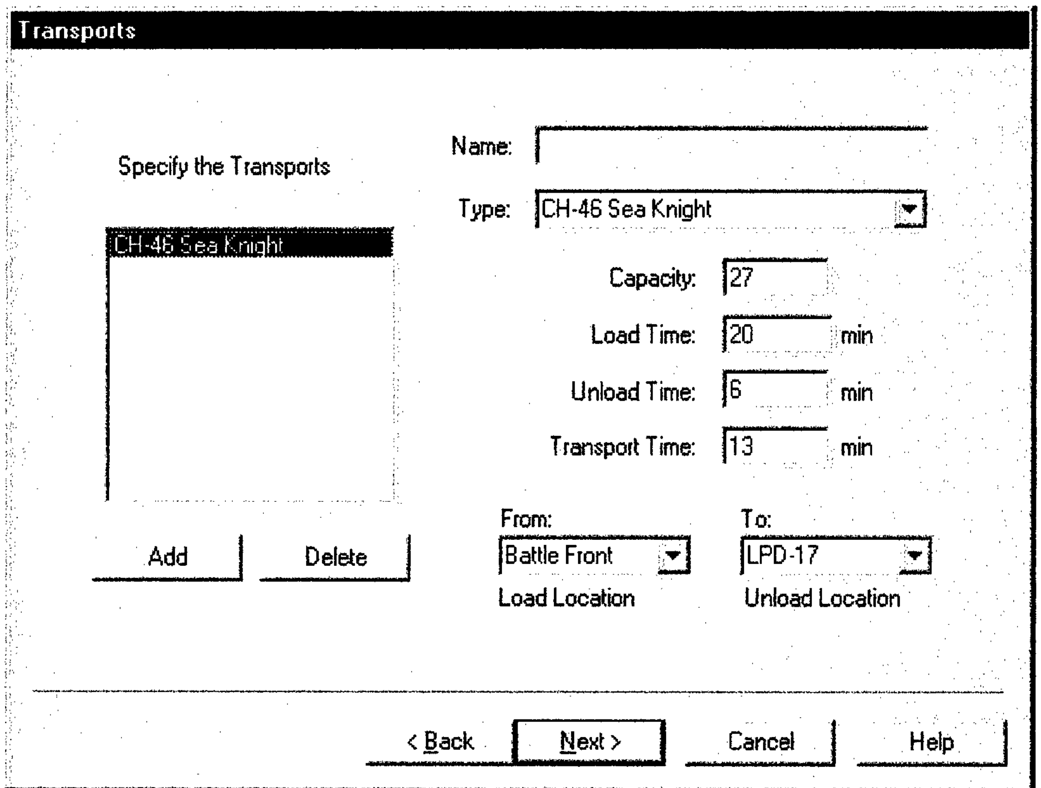
Future versions will provide support for specifying the day of the week for the work schedule and Specialties.

Transportation Selection

The last set of information required defines the transportation available between the battlefront and the MTFs. This lets you specify how many transports there are, where they operate between, and some of their characteristics.

To add a new transport, click the [Add] button. A *New* transport will appear in the list box.

To change the details of any transport, select it in the list box and change the values on the right of the dialog box. You can change the name, the type, the capacity, the loading and unloading time, the loading location, the unloading location, and the transport time between the load and unloading locations.

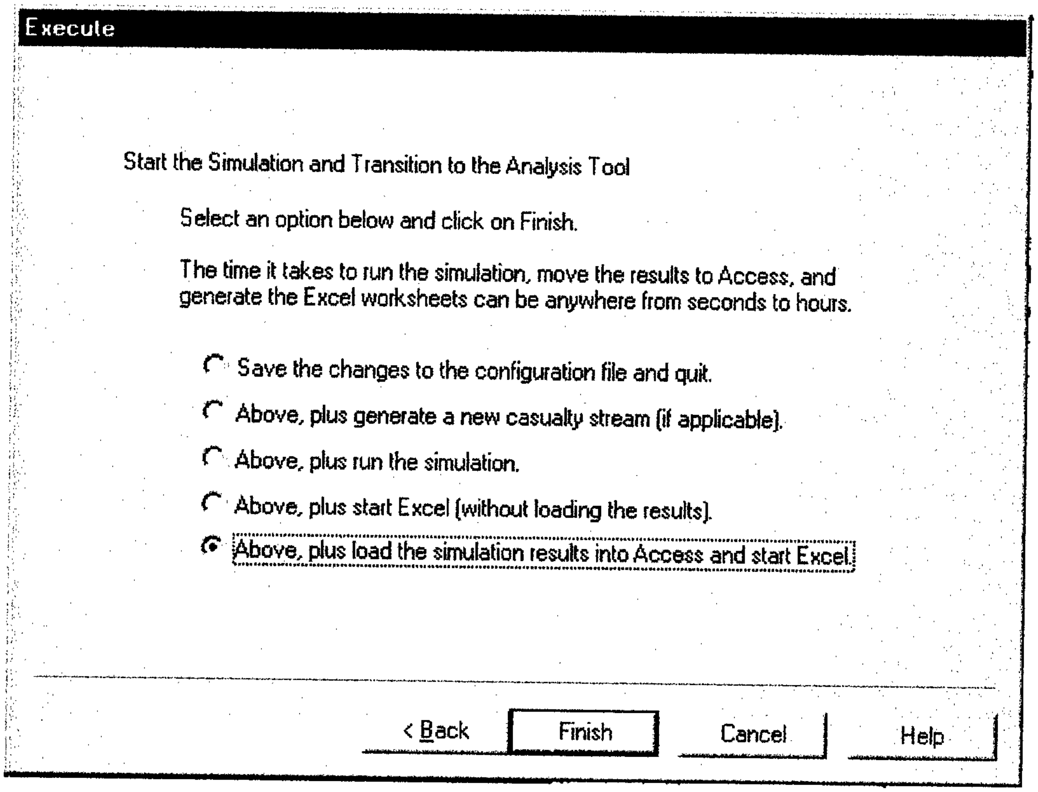


Execution Selection

The last step of running the CasFlow wizard is to specify exactly how much processing should be done. The choices, which build upon one another, are:

- Save the changes to the configuration file and quit.
- Above, plus generate a new casualty stream (if applicable).
- Above, plus run the simulation.
- Above, plus start Excel (without loading the results).
- Above, plus load the simulation results into an Access database and start Excel.

Depending on the length and complexity of the scenario, the time required for the simulation to run, create the Access database and run Excel can vary from minutes to hours.



KA Report: Casualty Rates

Appendix B

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Knowledge Acquisition Session Report

KA Session ID: MTG980202 **KA Session Date:** Feb. 2, 1998
Session Topic: Casualty Rates
Knowledge Engineers: Michael T. Gately, ScenPro, Inc.
Expert Name / Rank / Service : Christopher Blood, NHRC
Expert Phone Number: (619) 553-0730
Command Location: San Diego, CA
Session Location: e-mail
Type of Session:
_____ Interview _____ Task Analysis _____ Scenario Analysis
_____ Concept Analysis _____ Observation _____ Structured Interview
__X__ Other: _**Data Gathering**_______________________________

Initial Session : __X__
Documentation: KA Session Report, Casualty Rate Documents

Objectives

General Topic Area: Casualty rate information gathering and modeling.

Session Objectives: Researching how casualty rate information is collected, modeled, stored, and used in traditional medical care and to identify how those data can be collected, modeled, stored, and used for BW casualty care.

Report Summary

Chris Blood is an analyst at the Naval Health Research Center in San Diego, CA. His area of expertise includes gathering and modeling historical casualty rates for conventional trauma injuries. Casualty rate information can be used in a variety of ways – including modeling patient care, predicting resource needs, and predicting outcomes. The goal of this KA session was to research how casualty rate information is gathered, modeled, and stored

Results

Chris Blood was able to describe for us the various databases relating to casualty rates. He explained the process he and others go through to collect historical casualty rates – and how these data are to be interpreted. He further explained how to use these rates in a casualty stream generator to create a (historically accurate) casualty stream.

The following is an example of the information we got from Chris Blood. For medium-sized US Navy ships deployed in 1985 (during which time the US was not involved in any major conflicts) there were 4.04 occurances of upper respiratory infection per 1000 troop strength per day. That is, historically, for every 1000 seamen on medium-sized Naval ships, every day 4 of them, on average, caught some type of cold or flu.

Many collections of this type of data are available, such as ship-board vs. ashore, during combat vs. peace time, and Marines vs. US Navy.

Attached are two typical documents generated by people in this field such as Chris Blood. ScenPro has collected a number of these papers.

Knowing that this information is being used for conventional trauma injuries supports the idea that these data would be useful to collect and store for BW injuries.

MILITARY MEDICINE, 155, 7:31, 1990

Ship Size as a Factor in Illness Incidence among U.S. Navy Vessels

Christopher G. Blood, MA　　*Debra K. Griffith, BS*

Illness incidence was examined aboard U.S. Navy vessels to ascertain whether sick call rates vary with ship size. Outpatient data from ships of three different sizes (destroyers/frigates, cruisers, aircraft carriers) were surveyed, controlling for geographical region of deployment. Overall rates of illness were lower for the largest ships when contrasted with the smallest vessels for all three operational theaters; these rate differences were significant for the East Asia and Indian Ocean regions. Among major categories of disease, significantly higher rates aboard the small vessels were seen in at least two of the geographic regions for respiratory disorders, digestive diseases, and musculoskeletal problems. Infective and parasitic diseases, skin and subcutaneous disorders, as well as symptoms and ill-defined disorders were significantly higher for small ships in one theater. It was concluded that ship size is a factor in illness incidence and should be considered in medical resource planning.

Introduction

The effectiveness of the U.S. Navy and the success of the missions undertaken are greatly affected by the health of the constituent personnel. Optimal levels of readiness can be maintained only if the number of crew members incapacitated due to illness is minimized. The ability to predict illness rates for various operational scenarios allows projections to be made regarding personnel requirements and needed medical supplies. Geographical region of ship deployment recently was shown to be a factor in illness incidence, with lower rates of health problems witnessed among ships deployed to Europe than with vessels in the East Asia theater.[1]

Previous research by Gunderson and Erickson[2] investigating illness rates aboard the Navy's small ships (destroyers and frigates) indicated a similar influence of operational theater but found no systematic differences in morbidity rates between destroyers and frigates. Illnesses also have been examined aboard the midlevel-sized cruisers[3] as well as the largest ships—aircraft carriers.[4] These previous studies have looked at various types of vessels but none have collectively surveyed illness rates across small, medium, and large ships while controlling for geographic region.

The present study investigates the hypothesis that the internal environments associated with differently sized vessels have an impact on the health problems of the deployed crew members. Specifically, outpatient disease and nonbattle injuries will be examined to ascertain whether illness rates differ by ship size, and if so, whether the difference is constant across operational theaters.

Method

Two separate sources of outpatient data were used in an effort to determine differences in illness rates by size of ship. The first set of sickcall data was from a series of deployments during 1967–1973 on which outpatient visits were recorded.[5-7] Included in these East Asia deployments were 11 destroyers and frigates, 1 cruiser, and 4 aircraft carriers. The second source of illness data was a product of the Medical Services

Medical Decision Support Programs, Naval Health Research Center, P.O. Box 85122, San Diego, CA 92138-9174

Report No. 88-48, supported by the Naval Medical Research and Development Command, Department of the Navy under work unit M0095.005-1053. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government. Approved for public release, distribution unlimited.

This manuscript was received for review in March 1989 and was accepted for publication in August 1989.

and Outpatient Morbidity Reporting System.[7] The Monthly Morbidity reports, as they are commonly known, are completed by each ship and maintained at the Naval Medical Data Services Center, Bethesda, Maryland. Morbidity data collected during 1985 from two operational theaters were examined: within the Indian Ocean the ships were 3 destroyer/frigates, 1 cruiser, and 2 carriers; the various-sized ships deployed to the European theater were 5 destroyers/frigates, 3 cruisers, and 1 carrier. Illness data is reported in diagnostic categories corresponding to the International Classification of Diseases. Command History data, maintained at the Naval Historical Center, Washington, DC, were used to determine ship deployment locales and time frames. Only those illnesses occurring while the ships were within the specific theaters were used in the rate calculations.

Illness rates are computed per 1000 strength per day. For both data sources only the initial visit for a specific illness per individual enters into the rate calculations; no follow-ups or revisits for the same illness are used in the disease tallies. Illness rates for midsized ships (cruisers) are presented for comparison purposes, but, because destroyers/frigates and carriers represent the two extremes in ship size, only these differences are tested. Ninety-five percent confidence limits based on the normal distribution were calculated to determine if the rates of the smallest ships (destroyers/frigates) differed significantly from the largest ships (carriers). Dunn's method of adjusting the significance level for multiple comparisons[8] has been applied.

Results

Frequencies and rates of medical disorders by ship size for East Asia, the Indian Ocean, and Europe are displayed in Tables I–III, respectively. Also included are the number of man-days on which the rates were based.

In all three theaters respiratory disorders were higher on the smallest ships than on the largest ships; among the East Asia and Europe deployments these differences were significant. The subcategory contributing most prominently to these differences was upper respiratory infections.

The three geographical regions also yielded higher rates of digestive disorders aboard the small ships when compared with the carriers; these rate differences were significant for all theaters. Subcategories of illness were not recorded among the digestive disorders.

During the East Asia and Europe deployments the rates of musculoskeletal disorders were significantly higher among destroyers/frigates than carriers. Subcategories of musculoskeletal disorders occurring on these deployments were not available.

TABLE I

ILLNESS INCIDENCE BY SHIP SIZE FOR EAST ASIA DEPLOYMENT 1967–1973

	Small		Medium		Large	
	Frequency	Rate	Frequency	Rate	Frequency	Rate
Infective and parasitic	1,112	2.976[a]	145	1.776	895	1.176
Diarrhea, dysentery, enteritis	189	.506[a]	26	.318	158	.208
Sexually transmitted diseases	720	1.927[a]	72	.882	554	.728
Dermatophytosis	138	.369[a]	17	.208	90	.118
Neoplasms	0	.000	1	.012	9	.012
Endocrine, nutritional and metabolic	2	.005	3	.037	19	.025
Blood and blood-forming organs	3	.008	0	.000	9	.012
Behavioral	109	.292[a]	16	.196	113	.148
Alcohol abuse	2	.005	7	.086	5	.007
Nervous system and sense organs	167	.447	39	.478	295	.388
Circulatory system	0	.000	9	.110	25	.033
Respiratory system	1,786	4.780[a]	159	1.948	1,373	1.804
Upper respiratory infection	1,013	2.711[a]	27	.331	403	.529
Influenza	68	.182	13	.159	219	.288
Digestive system	330	.883[a]	30	.368	247	.325
Genitourinary system	519	1.389	80	.980	909	1.194
Urethritis	332	.889	59	.723	555	.729
Skin and subcutaneous tissue	604	1.617[a]	90	1.103	912	1.198
Cellulitis	49	.131	10	.123	58	.076
Dermatitis	71	.190	52	.637	242	.318
Musculoskeletal system	276	.739[a]	5	.061	325	.427
Congenital anomalies	0	.000	2	.025	3	.004
Symptoms and ill-defined	84	.225	27	.331	129	.169
Headache	35	.094	16	.196	62	.081
Accidents, poisonings, and violence	661	1.769[a]	168	2.058	987	1.297
Total of major categories	5,653	15.131[a]	774	9.482	6,250	8.211
Number of mandays	373,615		81,630		761,157	

Rates are per 1000 strength per day.

[a] Rate is significantly higher (95% confidence level) than for larger ships.

TABLE II

ILLNESS INCIDENCE BY SHIP SIZE FOR INDIAN OCEAN DEPLOYMENT, 1985

	Small		Medium		Large	
	Frequency	Rate	Frequency	Rate	Frequency	Rate
Infective and parasitic	151	3.198	44	2.456	1.061	2.349
Diarrhea/dysentery/enteritis	2	.042	32	1.786	338	.748[b]
Sexually transmitted diseases	97	2.051[a]	2	.112	194	.430
Dermatophytosis	45	.952	7	.391	303	.671
Neoplasms	0	.000	0	.000	3	.007
Endocrine, nutritional and metabolic	0	.000	0	.000	4	.009
Blood and blood-forming organs	0	.000	0	.000	6	.013
Behavioral	7	.148	4	.223	78	.173
Alcohol abuse	2	.042	2	.112	12	.027
Nervous system and sense organs	21	.444	9	.502	183	.405
Circulatory system	2	.042	5	.279	52	.115
Respiratory system	115	2.432	34	1.895	1.008	2.232
Upper respiratory infection	106	2.242	34	1.896	650	1.439
Influenza	5	.106	0	.000	323	.715[b]
Digestive system	37	.782[a]	9	.502	81	.179
Genitourinary system	72	1.523	8	.446	475	1.052
Urethritis	70	1.480	7	.391	381	.844
Skin and subcutaneous tissue	114	2.411	27	1.507	739	1.636
Cellulitis	18	.381	9	.502	51	.113
Dermatitis	43	.909	0	.000	229	.507
Musculoskeletal system	45	.952	36	2.009	509	1.127
Congenital anomalies	0	.000	0	.000	0	.000
Symptoms and ill-defined	46	.973[a]	0	.000	167	.370
Headache	16	.338	0	.000	66	.146
Accidents, poisonings, and violence	48	1.015	39	2.177	615	1.362
Total of major categories	656	13.916[a]	215	11.999	4.981	11.030
Number of mandays	47.285		17.918		451.601	

Rates are per 1.000 strength per day
[a] Rate is significantly higher (95% confidence level) than for large ships
[b] Rate is significantly higher than for small ships

Within East Asia and the Indian Ocean, the infective and parasitic illness rates were higher on the destroyers/frigates when contrasted with the carriers; this difference was significant for the East Asia theater. The differences in this diagnostic category were mainly attributable to elevated rates of sexually transmitted diseases aboard the small ships. A significantly higher rate of incidence for the subcategory consisting of diarrhea, dysentery, and enteritis was seen on small ships in East Asia and large vessels in the Indian Ocean and European theater.

Within the East Asian and Indian Ocean regions, the category of Skin and Subcutaneous Tissue disorders yielded higher rates on the small ships when compared with the large vessels; this difference was significant for ships deployed to East Asia. Although not reaching a level of significance, rates of cellulitis were higher aboard destroyers/frigates for the two eastern theaters.

While only significant for the Indian Ocean region, the diagnostic category of Symptoms and Ill-Defined disorders indicated higher rates for the small ships when contrasted with the carriers in all regions. Contributing to the rate differences in this category was the subgrouping of headaches.

A nonsignificant trend of higher genitourinary disorder rates among destroyers and frigates than on carriers was witnessed across the three operational regions. The subcategory of urethritis was largely responsible for the differences within this diagnostic category.

The category of Accidents, Poisonings, and Violence yielded incongruous results across deployments. The rate of this category was significantly higher among small ships than for carriers in East Asia, while the opposite held true for the ships deployed to Europe. Although unsubstantiated in other regions, two other significant results were found for a single theater among the major diagnostic categories. A higher rate of behavioral (mental) disorders was evident on the small ships deployed to East Asia, and carriers in the European theater yielded a higher rate within the diagnostic category of Endocrine, Nutritional, and Metabolic disorders.

The overall rates, composed of the total of the 15 diagnostic categories, indicated a lower rate for the carriers when compared with the destroyers/frigates for each geographical theater; within East Asia and the Indian Ocean region these rate differences were significant.

Discussion

Overall illness incidence within the East Asian region and the Indian Ocean showed an inverse relationship between ship

TABLE III

ILLNESS INCIDENCE BY SHIP SIZE FOR EUROPE DEPLOYMENT, 1985

	Small		Medium		Large	
	Frequency	Rate	Frequency	Rate	Frequency	Rate
Infective and parasitic	130	1.062	78	1.341	238	1.558
Diarrhea/dysentery/enteritis	35	.256	17	.292	155	1.015[b]
Sexually transmitted diseases	11	.090	10	.172	8	.052
Dermatophytosis	51	.416	45	.774	50	.327
Neoplasms	0	.000	0	.000	0	.000
Endocrine, nutritional and metabolic	4	.033	0	.000	53	.347[b]
Blood and blood forming organs	0	.000	0	.000	0	.000
Behavioral	20	.163	4	.069	56	.367
Alcohol abuse	3	.024	0	.000	5	.033
Nervous system and sense organs	34	.278	26	.447	35	.229
Circulatory system	13	.106	17	.292	21	.137
Respiratory system	490	4.002[a]	244	4.195	371	2.429
Upper respiratory infection	438	3.577[a]	235	4.040	147	.962
Influenza	40	.327	8	.138	24	.157
Digestive system	83	.678[a]	57	.980	16	.105
Genitourinary system	36	.294	15	.258	25	.164
Urethritis	11	.090	7	.120	13	.085
Skin and subcutaneous tissue	171	1.396	79	1.358	233	1.525
Cellulitis	23	.188	14	.241	49	.321
Dermatitis	47	.384	4	.069	36	.236
Musculoskeletal system	157	1.282[a]	95	1.633	61	.399
Congenital anomalies	0	.000	0	.000	0	.000
Symptoms and ill-defined	77	.629	45	.774	90	.589
Headache	48	.392[a]	42	.722	19	.124
Accidents, poisonings, and violence	121	.988	133	2.286	467	3.057[b]
Total of major categories	1,336	10.910	793	13.633	1,666	10.905
Number of mandays	122,453		58,168		152,768	

Rates are per 1,000 strength per day.
[a] Rate is significantly higher (95% confidence level) than for large ships.
[b] Rate is significantly higher than for small ships.

size and illness rate across the three ship groupings—the smaller the ship, the greater was the total illness rate. For the European theater, although the largest ships exhibited a slightly lower rate than the smallest ships, the midsized ships were higher than both of these. The explanation for cruisers having a higher rate in this particular theater is not immediately apparent.

There were several significant findings evident in contrasting health problems aboard destroyers/frigates with those occurring aboard carriers. Foremost was the trend of higher rates of communicable disease aboard the smaller ships. Most apparent were the elevated respiratory rates and digestive tract disorders, but substantial differences also were seen for infective and parasitic rates, as well as skin disorders. These higher rates may be a result of working and living within a more closed environment in that the spread of infectious diseases is facilitated by restricted environs. It should be noted, however, that this relationship between illness and ship size may not be one of direct linkage per se. Rather, higher rates of infectious disease may result from differing ventilation or air circulation systems aboard the smaller vessels. Beyond the physical determinants of disease proliferation, numerous psychosocial factors have been linked to infectious disease incidence and reduced immunological competence.[10] A study by Dean et al.,[11] for example, investigating health and satisfaction aboard Navy ships, found modest positive correlations between measures of crowding and dispensary visits. Furthermore, it is very possible that the increased rates of small ships for the category of Symptoms and Ill-Defined, which is substantially accounted for by a higher rate of headaches, is partially due to living and working in a more closed environment.

Within the Infective and Parasitic Disease category it must be noted that much of the variance was due to sexually transmitted diseases. It is likely that the higher rate of sexually transmitted diseases is due to the greater length of time the smaller ships in this study stayed when visiting foreign ports. This factor also may explain the elevated rates of genitourinary disorders, much of which is accounted for by urethritis.

The last trend to be considered is that of higher rates of musculoskeletal disorders seen on the small ships. While this too may be related to the constrained space aboard destroyers and frigates, this restrictiveness might have been expected to manifest itself with higher accident rates aboard the small ships. In fact, carriers had higher accident rates in two theaters than did the small ships. Higher rates of hospitalization for accidents aboard carriers have been previously documented,[12] and this may be due to the tempo of operations and nature of work aboard these ships rather than linked directly to the ship size. Also, likelihood of off-duty accidents aboard carriers would be greater because of an increase in recreational areas accessible to crew members.

Size of ships, in addition to theater of operations appears to be a factor in illness incidence. Determinations of personnel requirements and necessary medical supplies should be made with ship size considered as well as any other pertinent factors.

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MEDICAL RESOURCE PLANNING: THE NEED TO USE A STANDARDIZED DIAGNOSTIC SYSTEM

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REPORT NO. 89-41

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BETHESDA, MARYLAND

TABLE 8. **FREQUENCIES AND RATES OF PROPOSED ICD-9 BATTLE INJURY CATEGORIES; PRIMARY DIAGNOSES AMONG U.S. MARINES IN VIETNAM**

DESCRIPTION	FREQUENCY	PERCENT	RATE*
MULTIPLE FRAGMENT WOUND BRAIN	656	1.3	0.00513
MULTIPLE FRAGMENT WOUND CHEST 7 8	561	1.1	0.00439
MULTIPLE FRAGMENT WOUND BACK	567	1.1	0.00444
WOUND BRAIN	429	0.8	0.00336
OPEN WOUND CHEST 8	519	1.0	0.00406 97
OPEN WOUND BACK	283	0.6	0.00221 97
OPEN WOUND SHOULDER/UPPER ARM	1348	2.6	0.01054 ~~83~~ 47
OPEN WOUND ELBOW,FOREARM,WRIST	1453	2.8	0.01137 53
OPEN WOUND HAND(S)/FINGERS	1291	2.5	0.01010
OPEN WOUND UPPER LIMB(S) MULTIPLE	2432	4.7	0.01902
OPEN WOUND BUTTOCKS	806	1.6	0.00630
OPEN WOUND HIP/THIGH	2661	5.1	0.02081 123
OPEN WOUND KNEE/LOWER LEG/ANKLE	3702	7.1	0.02896 131
OPEN WOUND FOOT/TOES	839	1.6	0.00656
OPEN WOUND LOWER LIMB(S) MULTIPLE	2115	4.1	0.01654
OPEN WOUNDS MULTIPLE OTHER & UNSPCD	13062	25.1	0.10217
CONTUSION SHOULDER/UPPER ARM	16	0.0	0.00013
CONTUSION ELBOW,FOREARM,WRIST	33	0.1	0.00026
CONTUSION HAND/FINGERS	18	0.0	0.00014
CONTUSION HIP,THIGH,LEG,ANKLE	116	0.2	0.00091
CONTUSION FOOT AND TOE(S)	18	0.0	0.00014
CONTUSION TRUNK	134	0.3	0.00105
AMPUTATION FOOT	134	0.3	0.00105

23

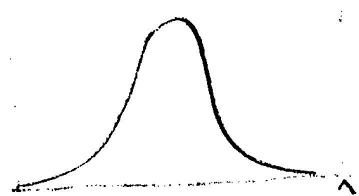
* RATES ARE PER 1,000 STRENGTH PER DAY.

9 - 6300

15 -

12 -

13062



0 0.00513

DESCRIPTION	FREQUENCY	PERCENT	RATE
13 AMPUTATION LEG(S)	498	1.0	0.00390 145
23 AMPUTATION TOES	39	0.1	0.00031
23 AMPUTATION FINGERS/THUMBS	188	0.4	0.00147
13 AMPUTATION ARMS/HANDS	117	0.2	0.00092 70
16 7 PNEUMOHEMOTHORAX	566	1.1	0.00443 183
5 INTRACRANIAL HEMORRHAGE POST INJURY 12	24	0.1	0.00019
10 CONCUSSION	676	1.3	0.00529
1 SPINAL CORD LESION NO BONE INJURY	29	0.1	0.00023
INJURY NERVES LOWER LEG	20	0.0	0.00016
INJURY NERVES UPPER ARM	22	0.0	0.00017
INJURY NERVES FOREARM	30	0.1	0.00023
INJURY NERVES THIGH	11	0.0	0.00009
INJURY NERVES FOOT & ANKLE	3	0.0	0.00002
INJURY NERVES WRIST/HAND	11	0.0	0.00009
~~10~~ INJURY NERVES CRANIAL 12	60	0.1	0.00047
OTHER UNSPECIFIED NERVE INJURY	24	0.1	0.00019
SUPERFICIAL WOUNDS	221	0.4	0.00173
MULTIPLE ORGAN DAMAGE	294	0.6	0.00230
4 WOUND LIVER 9	74	0.1	0.00058
9 WOUND KIDNEY	35	0.1	0.00027
4 WOUND PELVIC ORGANS	42	0.1	0.00033 177
4 WOUND SPLEEN 9	28	0.1	0.00022 177
9 WOUND GASTROINTESTINAL TRACT	199	0.4	0.00156 183
9 WOUND EXTERNAL GENITALIA	114	0.2	0.00089
5 INJURY HEART/LUNG 7	78	0.2	0.00061
22 WOUND SCALP	349	0.7	0.00273
6 WOUND FACE JAWS NECK 15	3333	6.4	0.02607 20
15 EYE WOUND	480	0.9	0.00375
22 OPEN WOUND EAR	634	1.2	0.00496
FOREIGN BODY EYE	57	0.1	0.00045

53

DESCRIPTION	FREQUENCY	PERCENT	RATE
3 BURNS LOWER EXTREMITIES 11 19	26	0.1	0.00020
3 BURNS TRUNK 11	21	0.0	0.00016
3 BURNS HEAD & NECK 11	21	0.0	0.00016
3 BURN EYE 11	22	0.0	0.00017
3 BURNS UPPER EXTREMITIES 11	79	0.2	0.00062
3 BURNS MULTIPLE OTHER & UNSPCD 11	552	1.1	0.00432
20 STRAINS/SPRAINS ANKLE/FOOT	233	0.5	0.00182
20 STRAINS/SPRAINS SACROILIAC	17	0.0	0.00013
20 SPRAIN WRIST/HAND/FINGERS	18	0.0	0.00014
20 STRAINS/SPRAINS KNEE	126	0.2	0.00099
20 SPRAINS & STRAINS MULT/OTHER/UNSPCD	348	0.7	0.00272
18 FRACTURE HAND/WRIST/FINGERS	915	1.8	0.00716
17 FRACTURE TIBIA & FIBULA	1413	2.7	0.01105
17 FRACTURE PELVIS	144	0.3	0.00113
FRACTURE SCAPULA	130	0.3	0.00102
14 FRACTURE SKULL LOC < 1 HOUR	0	0.0	0.00000
10 FRACTURE SKULL LOC 1-24 HOURS	0	0.0	0.00000
2 FRACTURE SKULL LOC > 24 HOURS	0	0.0	0.00000
FRACTURE SKULL NO/UNSPECIFIED LOC	273	0.5	0.00214
17 FRACTURE FEMUR	874	1.7	0.00684
18 FRACTURE UPPER LIMB	177	0.3	0.00138
17 FRACTURE LOWER LIMB	238	0.5	0.00186
7 FRACTURE RIB/STERNUM/LARYNX/TRACHEA 8 16	160	0.3	0.00125
18 FRACTURE RADIUS/ULNA	884	1.7	0.00691
18 FRACTURE HUMERUS	696	1.3	0.00544
18 FRACTURE CLAVICLE	79	0.2	0.00062
FRACTURE SPINE NO CORD DAMAGE	283	0.6	0.00221
FRACTURE SPINE WITH CORD DAMAGE	21	0.0	0.00016
17 FRACTURE ANKLE/FOOT/TOES	771	1.5	0.00603
17 FRACTURE PATELLA	82	0.2	0.00064

83

	DESCRIPTION	FREQUENCY	PERCENT	RATE
15	FRACTURE FACE BONES	554	1.1	0.00433
	FRACTURE MULTIPLE OTHER & UNSPCD	781	1.5	0.00611
17	DISLOCATION KNEE	162	0.3	0.00127
17	DISLOCATION ANKLE	4	0.0	0.00003
17	DISLOCATION HIP	4	0.0	0.00003
18	DISLOCATION SHOULDER	48	0.1	0.00038
17	DISLOCATION FOOT/TOES	3	0.0	0.00002
19	DISLOCATION HAND/WRIST	6	0.0	0.00005
19	DISLOCATION FINGERS	7	0.0	0.00005
18	DISLOCATION ELBOW	11	0.0	0.00009
15	DISLOCATION JAW	1	0.0	0.00001
	TOXIC INHALATION	9	0.0	0.00007
	TRAUMA-EARLY COMPLICATIONS	47	0.1	0.00037
	TRAUMA MULTIPLE OTHER & UNSPECIFIED	255	0.5	0.00199
	COMPLICATIONS MEDICAL CARE/SURGERY	15	0.0	0.00012
	98			
	TOTAL	51,959	100.0	0.40644

.00040644 per

8

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10

TABLE 10. FREQUENCIES AND RATES OF PROPOSED ICD-9 DNBI CATEGORIES; PRIMARY DIAGNOSES AMONG U.S. MARINES IN VIETNAM

DESCRIPTION	FREQUENCY	PERCENT	RATE*
FEBRILE ILLNESS EXCLUDING PNEUMONIA	13328	12.2	0.10425
FOOD POISONING BACTERIAL	44	0.0	0.00034 244
DIARRHEAL DISEASE/DYSENTERY	2376	2.2	0.01859
ENTERITIS SPECIFIED ORGANISM	21	0.0	0.00016
TUBERCULOSIS ALL TYPES	110	0.1	0.00086
MENINGOCOCCAL INFECTIONS	10	0.0	0.00008
HERPES SIMPLEX & HERPES ZOSTER	93	0.1	0.00073
ENCEPHALITIS	121	0.1	0.00095
HEPATITIS INFECTIOUS VIRAL	528	0.5	0.00413
ANIMAL BITES/RABIES EXPOSURE	1	0.0	0.00001
MUMPS	33	0.0	0.00026
INFECTIOUS MONONUCLEOSIS	456	0.4	0.00357
TRACHOMA	7	0.0	0.00005
STD-SYPHILIS	48	0.0	0.00038
STD-GONOCOCCAL INFECTIONS	363	0.3	0.00284
STD-OTHER VENEREAL DISEASES	260	0.2	0.00203
DERMATOPHYTOSIS & DERMATOMYCOSIS	1215	1.1	0.00950
HELMINTHIASIS	1755	1.6	0.01373
PEDICULOSIS	30	0.0	0.00023
SCABIES	6	0.0	0.00005
INFECTIVE & PARASITIC DISEASES OTHER	4098	3.8	0.03206
NEOPLASMS MALIGNANT	161	0.2	0.00126
NEOPLASMS BENIGN & UNSPECIFIED	1242	1.1	0.00972
THYROID DISORDER	48	0.0	0.00038

* RATES ARE PER 1,000 STRENGTH PER DAY.

DESCRIPTION	FREQUENCY	PERCENT	RATE
DIABETES MELLITUS	109	0.1	0.00085
ALLERGIC DISORDERS	126	0.1	0.00099
AVITAMINOSES/NUTRITIONAL DEFICIENCIES	123	0.1	0.00096
OBESITY & HYPERALIMENTATION	34	0.0	0.00027
ENDOCRINE/NUTRIT/METABOLIC DIS OTHER	203	0.2	0.00159
ANEMIAS ALL TYPES	180	0.2	0.00141
OTHER DIS BLOOD/BLOOD-FORMING ORGANS	342	0.3	0.00268
PSYCHOSIS	579	0.5	0.00453
NEUROSIS/PERSONALITY DIS/TSD/CONDUCT	3753	3.5	0.02936
ALCOHOL ABUSE	282	0.3	0.00221
DRUG ABUSE NON-ALCOHOL	201	0.2	0.00157
BEHAVIORAL DISORDERS OTHER	1098	1.0	0.00859
ENCEPHALITIS/MYELITIS/ENCEPHALOMYELIT	74	0.1	0.00058
EPILEPSY	99	0.1	0.00077
MIGRAINE	68	0.1	0.00053
CONJUNCTIVA DISORDER OF	239	0.2	0.00187
BLEPHARITIS/HORDEOLUM	48	0.0	0.00038
KERATITIS/IRITIS/CHOROIDITIS	139	0.1	0.00109
REFRACTIVE & ACCOMMODATION ERRORS	35	0.0	0.00027
OTITIS MEDIA & EXTERNA	605	0.6	0.00473
EAR & MASTOID OTHER DISEASES OF	1053	1.0	0.00824
EYE OTHER DISEASE OF	914	0.8	0.00715
NERVOUS SYST/SENSE ORGAN DISORD OTHER	1812	1.7	0.01417
RHEUMATIC DISEASE W/WOUT HEART INVOLV	48	0.0	0.00038
HYPERTENSIVE DISEASES	322	0.3	0.00252
ISCHEMIC HEART DISEASE ALL FORMS	28	0.0	0.00022
HEMORRHOIDAL DISEASE	764	0.7	0.00598
PHLEBITIS & THROMBOPHLEBITIS	212	0.2	0.00166
INTRACRANIAL HEMORRHAGE NON-TRAUMATIC	5	0.0	0.00004
CEREBROVASCULAR DISEASES OTHER	22	0.0	0.00017

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DESCRIPTION	FREQUENCY	PERCENT	RATE
ARTERIES/ARTERIOLES DISEASES OF	99	0.1	0.00077
CIRCULATORY SYSTEM DISEASES OTHER	583	0.5	0.00456
PHARYNGITIS/NASOPHARYNGITIS/SINUSITIS	617	0.6	0.00483
UPPER RESPIRATORY INFECTIONS ACUTE	448	0.4	0.00350
BRONCHITIS & BRONCHIOLITIS	1019	0.9	0.00797
INFLUENZA	361	0.3	0.00282
PNEUMONIA ALL TYPES	960	0.9	0.00751
ASTHMA	348	0.3	0.00272
ALLERGIC RHINITIS/HAYFEVER	39	0.0	0.00031
PNEUMOTHORAX	86	0.1	0.00067
RESPIRATORY SYSTEM DISEASES OTHER	1498	1.4	0.01172
TEETH & SUPPORTING STRUCTURES DIS OF	255	0.2	0.00199
PEPTIC ULCER GASTRIC/DUODENAL	573	0.5	0.00448 250
GASTRITIS/DUODENITIS/ENTERITI/COLITIS	3332	3.1	0.02606
APPENDICITIS	956	0.9	0.00748
HERNIA ABDOMINAL CAVITY ALL TYPES	977	0.9	0.00764
LIVER DISEASE & CIRRHOSIS	248	0.2	0.00194
PANCREAS DISEASE OF	25	0.0	0.00020
DIGESTIVE SYSTEM DISEASES OTHER	785	0.7	0.00614
URETHRITIS NON-VENEREAL	159	0.2	0.00124
KIDNEY & URETER DISEASES OF	745	0.7	0.00583
BLADDER DISEASES OF	131	0.1	0.00102
URINARY TRACT/URETHRA DISEASES OTHER	343	0.3	0.00268
PROSTATE DISEASES OF	304	0.3	0.00238
REDUNDANT PREPUCE & PHIMOSIS	459	0.4	0.00359
MALE GENITAL ORGANS OTHER DISORDERS	1069	1.0	0.00836
BREAST DISEASES OF	77	0.1	0.00060
OVARY & FALLOPIAN TUBE DISEASES OF	1	0.0	0.00001
CERVIX/CERVIX UTERI DISEASES OF	0	0.0	0.00000
UTERUS/VAGINA/VULVA DISEASES OF	1	0.0	0.00001

DESCRIPTION	FREQUENCY	PERCENT	RATE
MENSTRUATION DISORDERS OF	0	0.0	0.00000
FEMALE GENITAL ORGANS OTHER DISEASES	0	0.0	0.00000
ECTOPIC PREGNANCY	0	0.0	0.00000
ABORTION SPONTANEOUS & INDUCED	0	0.0	0.00000
DELIVERY WITHOUT COMPLICATIONS	2	0.0	0.00002
DELIV/ANTE/POSTPARTUM COMPLICATIONS	5	0.0	0.00004
CARBUNCLES & FURUNCLES	386	0.4	0.00302
CELLULITIS AND ABSCESS	5469	5.0	0.04278
PILONIDAL CYST/ABSCESS	153	0.1	0.00120
DERMATITIS/DERMATOSIS/ECZEMA	549	0.5	0.00429
NAIL DISEASES OF	213	0.2	0.00167
SWEAT & SEBACEOUS GLANDS DISEASES OF	491	0.5	0.00384
ULCER SKIN CHRONIC	337	0.3	0.00264
OTHER INFECT SKIN & SUBCUTANEO TISSUE	2301	2.1	0.01800
ARTHRITIS & RHEUMATISM	258	0.2	0.00202
ARTHROPATHIES/JOINT DISORDS OTHER	1213	1.1	0.00949
INTERNAL DERANGEMENT JOINT	676	0.6	0.00529
INTERVERTEBRAL DISC DISORDER	276	0.3	0.00216
BONE & CARTILAGE DISORDERS	555	0.5	0.00434
SYNOVITIS BURSITIS TENOSYNOVITIS	582	0.5	0.00455
MUSCULOSKELETAL/CONNECTIVE DIS OTHER	797	0.7	0.00623
CONGENITAL ANOMALIES	317	0.3	0.00248
PERINATAL MORBIDITY & MORTALITY	1	0.0	0.00001
HEADACHE	307	0.3	0.00240
UREMIA	13	0.0	0.00010
OTHER SYMPTOMS/ILL-DEFINED CONDITIONS	14377	13.2	0.11246
EFFECTS REDUCED TEMP/EXCESS DAMPNESS	704	0.7	0.00551
EFFECTS HEAT/LIGHT	1567	1.4	0.01226
EFFECTS OTHER EXTERNAL CAUSES	44	0.0	0.00034
ADVERSE EFFECTS MEDICINAL SUBSTANCES	146	0.1	0.00114

DESCRIPTION	FREQUENCY	PERCENT	RATE	
ADVERSE EFFECTS INDUSTRIAL SUBSTANCES	168	0.2	0.00131	
TOXIC EFFECT SUBSTANCES UNSPECIFIED	42	0.0	0.00033	
ADV EFFECT BAROMETRIC PRESSUR CHANGES	0	0.0	0.00000	
MULTIPLE FRAGMENT WOUND BRAIN	69	0.1	0.00054	
MULTIPLE FRAGMENT WOUND CHEST	79	0.1	0.00062	
MULTIPLE FRAGMENT WOUND BACK	37	0.0	0.00029	
WOUND BRAIN	101	0.1	0.00079	
OPEN WOUND CHEST	35	0.0	0.00027	91
OPEN WOUND BACK	32	0.0	0.00025	97
OPEN WOUND SHOULDER/UPPER ARM	132	0.1	0.00103	47
OPEN WOUND ELBOW,FOREARM,WRIST	273	0.3	0.00214	53
OPEN WOUND HAND(S)/FINGERS	992	0.9	0.00776	
OPEN WOUND UPPER LIMB(S) MULTIPLE	196	0.2	0.00153	
OPEN WOUND BUTTOCKS	66	0.1	0.00052	
OPEN WOUND HIP/THIGH	345	0.3	0.00270	123
OPEN WOUND KNEE/LOWER LEG/ANKLE	769	0.7	0.00602	131
OPEN WOUND FOOT/TOES	542	0.5	0.00424	
OPEN WOUND LOWER LIMB(S) MULTIPLE	161	0.2	0.00126	
OPEN WOUNDS MULTIPLE OTHER & UNSPCD	859	0.8	0.00672	
CONTUSION SHOULDER/UPPER ARM	34	0.0	0.00027	
CONTUSION ELBOW,FOREARM,WRIST	47	0.0	0.00037	
CONTUSION HAND/FINGERS	59	0.0	0.00046	
CONTUSION HIP,THIGH,LEG,ANKLE	369	0.3	0.00289	
CONTUSION FOOT AND TOE(S)	111	0.1	0.00087	
CONTUSION TRUNK	361	0.3	0.00282	
AMPUTATION FOOT	12	0.0	0.00009	
AMPUTATION LEG(S)	32	0.0	0.00025	145
AMPUTATION TOES	24	0.0	0.00019	
AMPUTATION FINGERS/THUMBS	201	0.2	0.00157	
AMPUTATION ARMS/HANDS	30	0.0	0.00023	70

DESCRIPTION	FREQUENCY	PERCENT	RATE	
PNEUMOHEMOTHORAX	50	0.0	0.00039	183
INTRACRANIAL HEMORRHAGE POST INJURY	21	0.0	0.00016	
CONCUSSION	444	0.4	0.00347	
SPINAL CORD LESION NO BONE INJURY	29	0.0	0.00023	
INJURY NERVES LOWER LEG	29	0.0	0.00023	
INJURY NERVES UPPER ARM	35	0.0	0.00027	
INJURY NERVES FOREARM	38	0.0	0.00030	
INJURY NERVES THIGH	18	0.0	0.00014	
INJURY NERVES FOOT & ANKLE	19	0.0	0.00015	
INJURY NERVES WRIST/HAND	39	0.0	0.00031	
INJURY NERVES CRANIAL	71	0.1	0.00056	
OTHER UNSPECIFIED NERVE INJURY	43	0.0	0.00034	
SUPERFICIAL WOUNDS	461	0.4	0.00361	
MULTIPLE ORGAN DAMAGE	45	0.0	0.00035	
WOUND LIVER	10	0.0	0.00008	
WOUND KIDNEY	31	0.0	0.00024	
WOUND PELVIC ORGANS	12	0.0	0.00009	177
WOUND SPLEEN	18	0.0	0.00014	177
WOUND GASTROINTESTINAL TRACT	31	0.0	0.00024	183
WOUND EXTERNAL GENITALIA	42	0.0	0.00033	
INJURY HEART/LUNG	11	0.0	0.00009	
WOUND SCALP	168	0.2	0.00131	
WOUND FACE JAWS NECK	388	0.4	0.00304	20
EYE WOUND	215	0.2	0.00168	
OPEN WOUND EAR	144	0.1	0.00113	
FOREIGN BODY EYE	70	0.1	0.00055	
BURNS LOWER EXTREMITIES	134	0.1	0.00105	
BURNS TRUNK	57	0.0	0.00045	
BURNS HEAD & NECK	62	0.1	0.00048	
BURN EYE	40	0.0	0.00031	

976
928
887.2
941.4

DESCRIPTION	FREQUENCY	PERCENT	RATE
BURNS UPPER EXTREMITIES	197	0.2	0.00154
BURNS MULTIPLE OTHER & UNSPCD	784	0.7	0.00613
STRAINS/SPRAINS ANKLE/FOOT	1100	1.0	0.00860
STRAINS/SPRAINS SACROILIAC	71	0.1	0.00056
SPRAIN WRIST/HAND/FINGERS	59	0.1	0.00046
STRAINS/SPRAINS KNEE	463	0.4	0.00362
SPRAINS & STRAINS MULT/OTHER/UNSPCD	1231	1.1	0.00963
FRACTURE HAND/WRIST/FINGERS	632	0.6	0.00494
FRACTURE TIBIA & FIBULA	510	0.5	0.00399
FRACTURE PELVIS	66	0.1	0.00052
FRACTURE SCAPULA	21	0.0	0.00016
FRACTURE SKULL LOC < 1 HOUR	0	0.0	0.00000
FRACTURE SKULL LOC 1-24 HOURS	0	0.0	0.00000
FRACTURE SKULL LOC > 24 HOURS	0	0.0	0.00000
FRACTURE SKULL NO/UNSPECIFIED LOC	122	0.1	0.00095
FRACTURE FEMUR	175	0.2	0.00137
FRACTURE UPPER LIMB	53	0.0	0.00041
FRACTURE LOWER LIMB	62	0.1	0.00048
FRACTURE RIB/STERNUM/LARYNX/TRACHEA	68	0.1	0.00053
FRACTURE RADIUS/ULNA	378	0.4	0.00296
FRACTURE HUMERUS	137	0.1	0.00107
FRACTURE CLAVICLE	90	0.1	0.00070
FRACTURE SPINE NO CORD DAMAGE	257	0.2	0.00201
FRACTURE SPINE WITH CORD DAMAGE	14	0.0	0.00011
FRACTURE ANKLE/FOOT/TOES	838	0.8	0.00656
FRACTURE PATELLA	57	0.0	0.00045
FRACTURE FACE BONES	613	0.6	0.00480
FRACTURE MULTIPLE OTHER & UNSPCD	151	0.1	0.00118
DISLOCATION KNEE	711	0.7	0.00556
DISLOCATION ANKLE	19	0.0	0.00015

204

DESCRIPTION	FREQUENCY	PERCENT	RATE
DISLOCATION HIP	16	0.0	0.00013
DISLOCATION SHOULDER	242	0.2	0.00189
DISLOCATION FOOT/TOES	17	0.0	0.00013
DISLOCATION HAND/WRIST	11	0.0	0.00009
DISLOCATION FINGERS	27	0.0	0.00021
DISLOCATION ELBOW	33	0.0	0.00026
DISLOCATION JAW	8	0.0	0.00006
TOXIC INHALATION	24	0.0	0.00019
TRAUMA-EARLY COMPLICATIONS	206	0.2	0.00161
TRAUMA MULTIPLE OTHER & UNSPECIFIED	442	0.4	0.00346
COMPLICATIONS MEDICAL CARE/SURGERY	336	0.3	0.00263
SUPPLEMENTAL CLASSIFICATION	1653	1.5	0.01293
TOTAL	108955	100.0	0.85227

KA Report: Development of Active Data Template Tool for Casualty Representation

Appendix C

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Knowledge Acquisition Development Report

Effort ID: MTG980204 **KA Session Date:** Feb. 4, 1998
Topic: Development of Active Data Template Tool for Casualty Representation
Engineers: Michael T. Gately, ScenPro, Inc.
Initial Session : __X__
Documentation: Knowledge Acquisition Development Report, Copy of prototype software, Copy of data template

Objectives

General Topic Area: Active Data Templates

Session Objectives: Do research into a tool to support Casualty Stream Generation using Active Data Templates.

Report Summary

Did research into casualty generation for BW scenarios. A file of data representing casualty rates was used to produce a file representing a random casualty stream mimicking the original data's probabilities.

NOTES

The attached files include the prototype code generated, the casualty rate file, and a sample output file. The example run to produce the output file has 39,000 soldiers fighting ashore for 60 days. There are a total of 945 casualties.

```
#include "stdio.h"
#include "stdlib.h"

#define NUM_INJURIES 98
#define MAX_PER_DAY 100


/*-------------------------------------------------------*/
double UniForm(long iSeed)
{
  long  Z, k;
  static long jSeed = 536870911;
  static long kSeed =   8388607;    /* 2^23-1 */

  if(iSeed != 0)
  {
    jSeed = abs(iSeed);
    kSeed = 8388607;
  }

  k = jSeed / 53668;

  jSeed = 40014 * (jSeed - k*53668) - k * 12211;

  if(jSeed < 0)
    jSeed += 2147483563;

  k = kSeed / 52774;

  kSeed = 40692 * (kSeed - k*52774) - k * 3791;

  if(kSeed < 0)
    kSeed += 2147483399;

  Z = jSeed - kSeed;

  if(Z < 1)
    Z += 2147483562;

  return (4.65661305739177e-10 * (double)Z);
}

/*-------------------------------------------------------*/

main (void)
{
  int bFound;
  int abAnyLeft[NUM_INJURIES];
  int i, j, iDay, iInj, iMan;
  int iNumSoldiers;
  int iNumDays;
  //int iNumInjToday;
  int iEarliestSoFar;
  int iTotalCasualties = 0;
  int iTotalCasualtiesEver = 0;
  int aiWhichNext[NUM_INJURIES];
  int aiNumCas[NUM_INJURIES];
  int aiSumOfInjuries[NUM_INJURIES];
  int long tTemp;
  int long tNewTime;
  int long tEarliestSoFar;
  int long ilTotalMinuteCounter;
  int long atTime[NUM_INJURIES][MAX_PER_DAY];
```

```
unsigned int uiSeed;
double dRan, dSum;
double dTotalRate;
double afInjuryRates[NUM_INJURIES];
FILE * fp;


//Load configuration file
iNumSoldiers = 39000;
iNumDays     = 60;
uiSeed       = 1958;


//Load injury rate file
afInjuryRates[0] = 0.00513;
afInjuryRates[1] = 0.00439;
afInjuryRates[2] = 0.00444;
afInjuryRates[3] = 0.00336;
afInjuryRates[4] = 0.00406;
afInjuryRates[5] = 0.00221;
afInjuryRates[6] = 0.01054;
afInjuryRates[7] = 0.01137;
afInjuryRates[8] = 0.01010;
afInjuryRates[9] = 0.01902;
afInjuryRates[10] = 0.00630;
afInjuryRates[11] = 0.02081;
afInjuryRates[12] = 0.02896;
afInjuryRates[13] = 0.00656;
afInjuryRates[14] = 0.01654;
afInjuryRates[15] = 0.10217;
afInjuryRates[16] = 0.00013;
afInjuryRates[17] = 0.00026;
afInjuryRates[18] = 0.00014;
afInjuryRates[19] = 0.00091;
afInjuryRates[20] = 0.00014;
afInjuryRates[21] = 0.00105;
afInjuryRates[22] = 0.00105;
afInjuryRates[23] = 0.00390;
afInjuryRates[24] = 0.00031;
afInjuryRates[25] = 0.00147;
afInjuryRates[26] = 0.00092;
afInjuryRates[27] = 0.00443;
afInjuryRates[28] = 0.00019;
afInjuryRates[29] = 0.00529;
afInjuryRates[30] = 0.00023;
afInjuryRates[31] = 0.00016;
afInjuryRates[32] = 0.00017;
afInjuryRates[33] = 0.00023;
afInjuryRates[34] = 0.00009;
afInjuryRates[35] = 0.00002;
afInjuryRates[36] = 0.00009;
afInjuryRates[37] = 0.00047;
afInjuryRates[38] = 0.00019;
afInjuryRates[39] = 0.00173;
afInjuryRates[40] = 0.00230;
afInjuryRates[41] = 0.00058;
afInjuryRates[42] = 0.00027;
afInjuryRates[43] = 0.00033;
afInjuryRates[44] = 0.00022;
afInjuryRates[45] = 0.00156;
afInjuryRates[46] = 0.00089;
afInjuryRates[47] = 0.00061;
afInjuryRates[48] = 0.00273;
afInjuryRates[49] = 0.02607;
```

```
afInjuryRates[50] = 0.00375;
afInjuryRates[51] = 0.00496;
afInjuryRates[52] = 0.00045;
afInjuryRates[53] = 0.00020;
afInjuryRates[54] = 0.00016;
afInjuryRates[55] = 0.00016;
afInjuryRates[56] = 0.00017;
afInjuryRates[57] = 0.00062;
afInjuryRates[58] = 0.00432;
afInjuryRates[59] = 0.00182;
afInjuryRates[60] = 0.00013;
afInjuryRates[61] = 0.00014;
afInjuryRates[62] = 0.00099;
afInjuryRates[63] = 0.00272;
afInjuryRates[64] = 0.00716;
afInjuryRates[65] = 0.01105;
afInjuryRates[66] = 0.00113;
afInjuryRates[67] = 0.00102;
afInjuryRates[68] = 0.00001;
afInjuryRates[69] = 0.00001;
afInjuryRates[70] = 0.00001;
afInjuryRates[71] = 0.00214;
afInjuryRates[72] = 0.00684;
afInjuryRates[73] = 0.00138;
afInjuryRates[74] = 0.00186;
afInjuryRates[75] = 0.00125;
afInjuryRates[76] = 0.00691;
afInjuryRates[77] = 0.00544;
afInjuryRates[78] = 0.00062;
afInjuryRates[79] = 0.00221;
afInjuryRates[80] = 0.00016;
afInjuryRates[81] = 0.00603;
afInjuryRates[82] = 0.00064;
afInjuryRates[83] = 0.00433;
afInjuryRates[84] = 0.00611;
afInjuryRates[85] = 0.00127;
afInjuryRates[86] = 0.00003;
afInjuryRates[87] = 0.00003;
afInjuryRates[88] = 0.00038;
afInjuryRates[89] = 0.00002;
afInjuryRates[90] = 0.00005;
afInjuryRates[91] = 0.00005;
afInjuryRates[92] = 0.00009;
afInjuryRates[93] = 0.00001;
afInjuryRates[94] = 0.00007;
afInjuryRates[95] = 0.00037;
afInjuryRates[96] = 0.00199;
afInjuryRates[97] = 0.00012;


//Clean some variables
dTotalRate = 0.0;
for(i = 0; i < NUM_INJURIES; i++)
{
  //aiNumCas[i]        = 0;
  //aiWhichNext[i]     = 0;
  //abAnyLeft[i]       = 0;
  aiSumOfInjuries[i] = 0;
  dTotalRate         = dTotalRate + afInjuryRates[i];
}
dTotalRate = dTotalRate / 1000.0;


//Set random number seed
```

```
//srand(uiSeed);
dRan = UniForm(uiSeed);


//Open output file
fp = fopen("out.dat", "w");


//Compute casualty stream
//For each day
for(iDay=0;iDay<iNumDays;iDay++)
{
  //Clean up the data structures
  for(i=0;i<NUM_INJURIES;i++)
  {
    aiNumCas[i]    = 0;
    aiWhichNext[i] = 0;
    abAnyLeft[i]   = 0;
  }
  ilTotalMinuteCounter = iDay * 86400;

  //For each soldier going into battle
  for(iMan=0; iMan<iNumSoldiers; iMan++)
  {
    //See if they get injured
    dRan = UniForm(0);
    if(dRan <= dTotalRate)
    {
      //See which injury they have
      dSum = 0.0;
      dRan = dRan * 1000.0;
      for(iInj = 0; iInj < NUM_INJURIES; iInj++)
      {
        dSum = dSum + afInjuryRates[iInj];
        if(dRan < dSum)
        {
          //FOUND THE INJURY!!!
          iTotalCasualtiesEver++;
          aiSumOfInjuries[iInj]++;
          //Check that the data structure isn't too small
          if(aiNumCas[iInj] > MAX_PER_DAY)
          {
            printf("Injury %i had more than %i casualties on day %i.\n",
             iInj, MAX_PER_DAY, iDay);
            aiNumCas[iInj] = MAX_PER_DAY;
          }
          //Now figure out when the casualty occured
          dRan = UniForm(0);
          tNewTime = (int)(dRan * 86400);
          if(aiNumCas[iInj] == 0)
          {
            atTime[iInj][0] = tNewTime;
            aiNumCas [iInj] = 1;
          }
          else
          {
            bFound = 0;
            for(i=0; i<aiNumCas[iInj]; i++)
            {
              if(tNewTime < atTime[iInj][i])
              {
                j=i;
                while(j<aiNumCas[iInj])
                {
```

```
                    tTemp=atTime[iInj][j];
                    atTime[iInj][j] = tNewTime;
                    tNewTime = tTemp;
                    j++;
                  }
                  atTime[iInj][aiNumCas[iInj]++] = tNewTime;
                  bFound = 1;
                  break;
                }
              }
              if(!bFound)
              {
                atTime[iInj][aiNumCas[iInj]++] = tNewTime;
              }
            }
            abAnyLeft[iInj] = 1;
            iTotalCasualties++;
            break;
          }
        }
      }
    }

    //Now print them out
    while(iTotalCasualties > 0)
    {
      tEarliestSoFar = (iDay+1) * 86400 + 1;
      for(i=0;i<NUM_INJURIES;i++)
      {
        if(abAnyLeft[i])
        {
          if(atTime[i][aiWhichNext[i]] < tEarliestSoFar)
          {
            tEarliestSoFar = atTime[i][aiWhichNext[i]];
            iEarliestSoFar = i;
          }
        }
      }
      tTemp = tEarliestSoFar + ilTotalMinuteCounter;
      fprintf(fp,"%li %i\n", tTemp, iEarliestSoFar);
      aiWhichNext[iEarliestSoFar]++;
      abAnyLeft[iEarliestSoFar] = (aiWhichNext[iEarliestSoFar] <
                                   aiNumCas[iEarliestSoFar]);
      iTotalCasualties--;
    }
  }

  //Close output file
  fclose(fp);

  return 0;
}
```

1467	62
20623	29
38047	83
38190	39
38529	23
44332	0
56405	15
68861	76
87646	11
90488	12
90786	6
94358	15
103209	25
103691	76
105618	64
109828	12
124418	15
140775	23
143852	15
144046	15
144257	2
166640	13
167156	15
184927	15
191278	15
193864	11
195809	76
196089	71
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209243	11
210421	72
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215470	9
221976	12
240053	12
244672	14
254466	81
255290	15
266337	65
279092	11
279894	8
299987	15
313019	6
326172	15
338982	15
339900	11
340850	49
342440	52
367289	65
369034	7
370230	58
370663	15
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377597	81
381207	9
399276	15
404839	14
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428390	15
429370	11
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473544	58
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480249	15
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520888	15
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613858	12
618884	48
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629202	15
629489	9
629598	43
641466	10
646158	4
651266	9
656672	15
662286	11
668786	76
672373	12
685815	71
688415	0
693521	7
694881	9
702413	8
705218	8
714950	64
726272	11
731842	8
732078	15
732348	15
749749	12
753372	6
757641	12
765420	9
769269	14
776298	49
777451	15

785772	11
787727	14
803150	12
806102	15
813256	74
814997	72
819679	12
826881	64
827167	7
828732	48
839546	6
840329	49
844152	15
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847462	6
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1068842	72
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1101875	15
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2782793	15
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4082985	64
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4152522	27
4156547	49
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KA Report: Chemical Scenario involving US Navy ship LPD-17

Appendix D

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Knowledge Acquisition Session Report

KA Session ID: MTG980211 **KA Session Date:** Feb. 11, 1998
Session Topic: Chemical Scenario involving US Navy ship LPD-17
Knowledge Engineers: Michael T. Gately, ScenPro, Inc.
Expert Name / Rank / Service : Sally Veasey
Expert Phone Number:
Command Location:
Session Location: phone&e-mail **Time:** 10:00 a.m.
Type of Session:
_____ Interview _____ Task Analysis __X__ Scenario Analysis
_____ Concept Analysis _____ Observation _____ Structured Interview
_____ Other: ____

Initial Session : __X__
Documentation: KA Session Report, Tunisia Scenario

Objectives

General Topic Area: Develop a scenario using both chemical warfare and the LPD-17.

Session Objectives: Work with a contingency/planning expert to generate a reasonable scenario involving a large deck amphibious ship.

Report Summary

Worked with LtC Sally Veasey to generate "as is" and "to be" scenarios for a chem/bio incident response. She provided a lot of information about scenarios used for contingency planning where chemical or biological weapons may be used. She helped me work out a Noncombatant Evacuation Operation (NEO) involving the US Consulate Building in Tunis, Tunisia.

NOTES

Attached is the scenario generated from this session.

Event: Political Uprising in capitol city Tunisia - Evacuation of U.S. Citizens

---

Setting: U.S. Embassy in central Tunis

Background: The severe restrictions placed on Tunisia by the IMF during their financial crisis intervention in 1986 (arising from a sharp drop in agricultural output and tourism, combined with the oil price collapse) have demoralized many Tunisians. There was a brief resurgance of growth during the Gulf War, but since that time, GDP had again dropped to less than 2.0% - with much of the benefits going to the cronies of President Ben Ali of the Constitutional Democratic Rally Party (RCD).

The Movement of Democratic Socialists (MDS), lead by Mohammed Mouaada, have been plotting a revolution against the corrupt government. Yesterday a splinter group from the Tunisian Army, under the control of Mouaada, surrounded the government buildings in the heart of Tunis. The revolutionists are demanding the immediate disolution of the current government.

Including families, there are 213 Americans in Tunis associated with the State Department. They have all moved into the U.S. Embassy (144 Avenue de la Liberte, 1002 Tunis-Belvedere). In addition, according to State Department documents, there are 1,144 U.S. Citizens with work visas in Tunisia and approximately 300 travellers in the country - most in Tunis.

Features:

Problems include:

- limited evacuation routes
- language barrier
- lack of medical supplies
- weather
- hostile evacuation situation

Event Progression:

AUG 08

- Embassy contact DoD
- DoD issues orders to US Navy / Marine Corps for Non-combatant Evacuation Operation (NEO)
- Embassy personnel alert U.S. citizens (in Tunisia)

AUG 09

- US citizens/personnel arrive at embassy

AUG 10

- Ships (two large deck, amphibious) arrive Aug 10
- Marine Expeditionary Force comes ashore
    11 Marines are injured in explosion (engine & fuel tank on boat)

AUG 11

- Evacuation begins at 0530
- Marines & civilians are wounded in small arms fire
- Mustard gas (one canister) is released at 1123
- US military and civilian personnel in courtyard are affected (23 severe, 16 mild)
- Personnel are brought inside
- Helicopter pilot is severely exposed
- 48 minute delay for replacement helicopter pilot from LPD-17
- Replacement pilot arrives with chemical agent detection equipment
- Masks & MOPP gear are distributed
- Remaining personnel /civilians are evacuated

LPD-17-Oriented Scenario

8 AUG
The severe restrictions placed on Tunisia by the IMF during their financial crisis intervention in 1986 (arising from a sharp drop in agricultural output and tourism, combined with the oil price collapse) have demoralized many Tunisians. There was a brief resurgance of growth during the Gulf War, but since that time, GDP had again dropped to less than 2.0% - with much of the benefits going to the cronies of President Ben Ali of the Constitutional Democratic Rally Party (RCD).

The Movement of Democratic Socialists (MDS), lead by Mohammed Mouaada, have been plotting a revolution against the corrupt government. Yesterday a splinter group from the Tunisian Army, under the control of Mouaada, surrounded the government buildings in the heart of Tunis. The revolutionists are demanding the immediate disolution of the current government.

Including families, there are 213 Americans in Tunis associated with the State Department. They have all moved into the U.S. Embassy (144 Avenue de la Liberte, 1002 Tunis-Belvedere). In addition, according to State Department documents, there are 1,144 U.S. Citizens with work visas in Tunisia and approximately 300 travellers in the country - most in Tunis.

The Department of Defense has issued orders to the U.S. Navy and the U.S. Marines to perform a Non-combatant Evacuation Operation (NEO) on all non-support personnel at the U.S. Embassy in Tunis. Due to the proximity of the U.S. Embassy to the government section of the city - which is now ringed with tanks, the U.S. Marines are to be used as a Security Force.

Two large deck amphibious ships are to be sent to provide the Security Force and to aid in extricating the enconsed non-support personnel. As the airport and all major roads are under observation by, and possibly controlled by the revolutionary party, helicopters will be used for the evacuation.

8 AUG
CINCNAVEUR has ordered an Amphibious Ready Group (ARG) from the Sixth Fleet, currently in port in Sardinia, to go to Tunisia. Arrival time, 10 AUG. The ARG is composed of the Tarawa (LHA-1) and an LPD-17. Total troop strength is 2,400.

9 AUG
Members of the Tunisian Army loyal to President Ali have surrounded the revolutionary forces and are demanding their immediate surrender. At this point the U.S. Embassy has been largely ignored by the two factions. The number of U.S. citizens inside the Embassy compound has risen to 380, of which 354 need to be evacuated.

10 AUG
Tunis is all but closed. Tunisians are taking sides in the conflict - with many siding with the revolutionary party. Sporatic small arms weapons can be heard, no major military action has occured. The French Government has intervened in the conflict and is attempting to resolve the situation peacefully.

The Tarawa ARG has taken station off the coast of Tunis. Under cover of night the Marine Expeditionary Force came ashore and has made its way to the U.S. Embassy. One group of 11 marines were injured when the engine and fuel tank on their landing craft exploded. There have been a number of minor casualties from accidental encounters with soldiers from the Tunisian Army.

Evacuation will begin at first light.

11 AUG

Evacuation began at 5:30am local time. Two helicopters are shuttling the non-combatants to the LHA-1 and the LPD-17. Several Marines and non-combatants have been wounded from small arms fire. There was slight damage to an IR pod on one of the helicoptors.

At 11:23am, apparently under the direction of Mohammed Mouaada of the MDS, a single canister of Mustard Gas was released in the eastern portion of the city. The apparent target of the gas was the Tunisian Army, but the gas swept over the U.S. Embassy. Those Marines and civilians who were in the compound's courtyard loading a helicopter with non-combatants were overcome by the gas.

All personnel were immedately brought into the Embassy and a perimeter was established. Communication with the doctor on board the LPD-17 revealed the nature of the attack and gave guidance on immediate treatment, decontamination, and protection.

There were 23 individuals with high levels of exposure and an additional 16 with mild exposure. Because the helicopter pilot was one of those with high exposure, another pilot had to be brought from the LPD-17 - which introductd a 48 minute delay in starting the evacuation of the casualties.

Chemical agent detection equipment, which was brought with the replacement pilot, was used to determine that the Mustard gas had dissipated. All casualties were evacuated to the LPD-17. Gas masks and MOPP gear were deployed and the remainder of the evacuation proceeded without incident.

```
LPD-17 Casualty Stream
======================
8 AUG
  12 DNBI -
    3 GI
    1 Parasite
    4 Minor Lacerations
    4 mechanics involved in a boiler room explosion
      3 immediate with puncture wounds to the upper body
      1 delayed with a mild concussion

9 AUG
   7 DNBI -
     2 GI
     1 Flu
     3 minor lacerations
     1 radio tech who was electrocuted
       immedate

10 AUG
   6 DNBI -
     1 GI
     2 Parasites
     3 corpsman involved in a fuel spill
       1 immedate
       2 delayed
  11 Marines from explosion of engine and fuel tank
       8 immediate
       3 delayed
   2 Marines from fractures in travelling through city
       1 immediate
       1 delay
   9 Marines with bullet wounds
       6 immediate
       2 delay
       1 expectant
```

11 AUG
2 DNBI
11 with bullet wounds
4 fractures
23 with high exposure
16 with mild exposure

12 AUG
19 DNBI

KA Report: Casualty Scenario involving US Navy ship LPD-17

Appendix E

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Knowledge Acquisition Session Report

KA Session ID: MTG971217 **KA Session Date:** Dec. 17, 1997
Session Topic: Casualty Scenario involving US Navy ship LPD-17
Knowledge Engineers: Michael T. Gately, ScenPro, Inc.
Expert Name / Rank / Service : Dr. John Downs
Expert Phone Number:
Command Location:
Session Location: phone & e-mail **Time:** various
Type of Session:
_____ Interview _____ Task Analysis __X__ Scenario Analysis
_____ Concept Analysis _____ Observation _____ Structured Interview
_____ Other: ____

Initial Session : __X__
Documentation: KA Session Report, Guantanamo Scenario

Objectives

General Topic Area: Develop a peacetime casualty scenario involving the LPD-17.

Session Objectives: Work with a contingency/planning expert to generate a reasonable scenario involving peacetime casualties and a large deck amphibious ship.

Report Summary

Worked with Dr. John Downs to generate a scenario where peacetime operations result in casualties. He provided realistic information about the scenario.

NOTES

Attached is the scenario generated from this session.

Scenario: Marine Corps Removal of Landmines surrounding the Naval Air Station at Guantanamo Bay, Cuba

Physical: U.S. Naval Station at Guantanamo Bay
A platoon of marines stationed on the LPD-17 (echelon 2/3) have been sent to the east side of the compound to clear a mine field. Marines execute a beach landing using two landing boats. Casualties are first taken by landing boat to the LPD-17. After echelon 2/3 treatment, casualties are taken by medevac to the NAS Key West.

Casualty Flow:
9:00am 5 soldiers injured when landmine being clear accidentally detonated
- 2 severe leg wounds (131,145)
- 2 severe arm wounds (47, 53)
- 1 abdomen wound (177)

12:05pm 4 soldiers injured when their jeep ran over an undocumented landmine
- 1 severe leg wound (123)
- 2 severe arm wounds (53, 70)
- 1 neck wound (20)

1:00pm 2 DNBI
- 1 with food poisoning (244)
- 1 with a peptic ulcer (250)

Casualty Stream Resulting from the Mogadishu Raid

Appendix F
OF
Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Approved for public release; SBIR report, distribution unlimited

3 October 1993 Mogadishu Raid – 18 American killed, 79+ wounded

Killed in Action and Died of Wounds

1. Gunshot wound to the head (KIA)

2. Gunshot wound to upper thigh/femoral artery (KIA) – died after several hours awaiting evacuation)

3. Gunshot wound to shoulder followed by unexploded RPG to chest (KIA)

4. Helicopter crash followed by gunshot wound to back/neck (KIA)

5. Gunshot wound to upper back through soft body armor penetrating into abdomen (KIA)

6. Gunshot wound to leg and then to chest (DOW in Germany) (hospital report reads "Chest wound and R knee wound")

7. Blunt trauma injuries from helicopter crash (KIA)

8. Helicopter crash injuries and possible GSWs (KIA)

9. Gunshot wound(s) to various parts of body (unknown) (KIA)

10. Helicopter crash and possibly also GSW (KIA)

11. Helicopter crash and possible GSW (KIA)

12. Gunshot wound(s) to various parts of body (unknown) (KIA)

13. Helicopter crash injuries then gunshot wound to abdomen under body armor and another to part of body (unknown) (DOW)

14. Gunshot wound to head (KIA)

15. Gunshot wound to chest through soft body armor. Not wearing ceramic plate (DOW) (hospital report reads "GSW R side of chest")

16. Gunshot wound to head (KIA)

17. RPG to abdomen (DOW) (hospital report reads "GSW to hip")

18. Gunshot wound to head (KIA)

Wounded in Mogadishu Raid

1. Fall from a height during fast rope. Head injury and poss. Internal injuries

2. GSW to right hip. Bullet stopped by knife. Contusion and bullet fragments to thigh

3. GSW to left hand nearly severing left thumb. (hospital report reads "GSW Left Hand")

4. GSW to arm/shoulder

5. GSW ricochet round (? Location of injury)

6. GSW amputated end of finger (hospital report reads "GSW leg, Fx hand) ? Which finger?)

7. GSW to left shoulder

8. Helo crash with inj right leg (? Femur) Blunt trauma to face from rifle butt, hit with fists and kicked. Grabbed in the groin/testicles

9. GSW to forearm. Knocked unconscious later by RPG which struck vehicle killing PFC Richard Kowalewski. RPG did not explode- embedded in body.

10. Fragments and blast injury to legs from RPG

11. GSW to calf (which leg?) (hospital record for Harry Powell reads "GSW lower L leg and upper R leg")

12. GSW to left leg (GSW in both legs?). Shot again during evac in left foot. (hospital report reads "GSW both legs")

13. GSW hit by bullets – Body armor stopped bullet to chest but three bullets struck upper thighs of both legs. Struck again by a bullet while being carried to medical treatment. (hospital report reads "GSW leg / Wound to shoulder")

14. Hit by bullets? Body armor protected?? ?injury? Humvee hit by RPG blowing patient out of the moving vehicle. Injury to left thigh. Run over by 5-ton truck in confusion after RPG explosion. (hospital report reads "GSW L thigh")

15. Fragment to left forearm and hand from exploding RPG. Fractures of forearm and hand and lac of tendon. (hospital report reads "shrapnel left arm and hand")

16. Left arm and bilat feet w/frag wounds and burns from RPG (hospital report reads "GSW R knee L arm)

17. Blunt trauma to face from rifle during fast roping and later blown out of HUMVEE by exploding RPG – frag wounds/blast inj.

18. Injuries from RPG blast attenuated by bulletproof glass of HUMVEE. RPG hit metal door and then rolled down window inside door attenuating the blast.

19. GSW to back of left leg just below the knee. (hospital report reads "GSW to L lower leg")

20. GSW X 2 to both legs. Rounds attenuated by bullet proof glass. Forearm shatter by another bullet.

21. Hit in back of helmet by bullet causing momentary blindness. No penetration of Kevlar

22. Struck in the chest by bullet stopped by ceramic chest plate. Minor contusion. GSW to leg – bullet poked through metal door of HUMVEE was caught by bulletproof glass. Glass poked into patient's leg.

23. GSW to L calf muscle. Little pain.

24. Facial contusions/lacerations secondary to helicopter crash.

25. Tips of two fingers shot off. (hospital report reads "Left hand injury")

26. Bullet frags to face and arm.

27. Wound to hand from bullet / bullet fragments (No record of having been seen at 46th CSH)

28. Blast injury from frag grenade. Facial injuries, frag wounds to left leg and back (??GSW)

29. Hit with a small piece of shrapnel to left side from exploding RPG.

30. GSW right thigh/buttocks

31. GSW to right arm. (while firing M-60 machine gun) (hospital report reads "GSW R arm")

32. GSW to right arm (injured immediately after taking over M-60 machine gun) (hospital report reads "R arm injury")

33. GSW to right lower leg with near amputation (hospital record reads "Fx R leg")

34. GSW to foot (hospital report reads "GSW L ankle")

35. GSW (treated with PASGT for compression) through buttock, right testicle and into pelvis. (hospital report reads "Lac to scrotum")

36. RPG explosion with minor blast injury and contusions with frag injury to left leg and foot. Large fragment lodged in foot – felt no pain, just numbness (hospital report reads "Shrapnel wound left side")

37. Minor injuries from RPG explosion

38. GSW R ankle

39. 2d degree burns to upper and lower extremities

40. Fragmentation wounds to R and L arms

46. Minor burns and fracture

47. Shrapnel left shoulder and wrist

48. Shrapnel wound to face and right shoulder, grazing wounds

49. Shrapnel in back

50. GSW R shoulder

51. GSW L wrist and hand. Shrapnel to face and R leg

52. Shrapnel both legs and R finger amputation

53. GSW R elbow and L hand

54. GSW L leg R arm frag

55. L hip injury ? mech. Of injury

56. Chest injury ? mech of injury

57. Trauma to face, back. Frag wounds L arm

58. GSW R leg

59. R leg injury

60. GSW L forearm

61. GSW R arm and shrapnel L hand

62. Shrapnel L knee

63. Small wound on forehead. Minimal initial symptoms, no neuro deficits. Returned to duty. Returned several days later for c/o headache and fluid draining from wound. Found on x-ray to have a small fragment imbedded > 6 cm in brain. Developed seizures during MEDEVAC to Germany.

64. GSW R arm Head injury

65. Fx L arm

66. Frag wound both ankle and back

67. RPG grazed neck

68. Shrapnel R leg

69. Shrapnel R arm

70. GSW R elbow

71. GSW left shoulder

72. Shrapnel to back right side

73. Arm and L ankle injury (prob. non-penetrating injury)

74. GSW to neck

75. GSW left hand 4 & 5 finger

76. Shrapnel wound to neck

77. GSW or fragment wound to left buttocks

78. Broken nose – blunt trauma

79. Injured when RPG struck his vehicle but did not explode. No record of being seen at or admitted to 46th CSH but was apparently in some type of MTF for medical care.

Soldiers Involved in TF Ranger Who Were Injured Prior to TF Ranger (not inclusive)

Injured elbow prior to TR Ranger raid while wrestling with a colonel

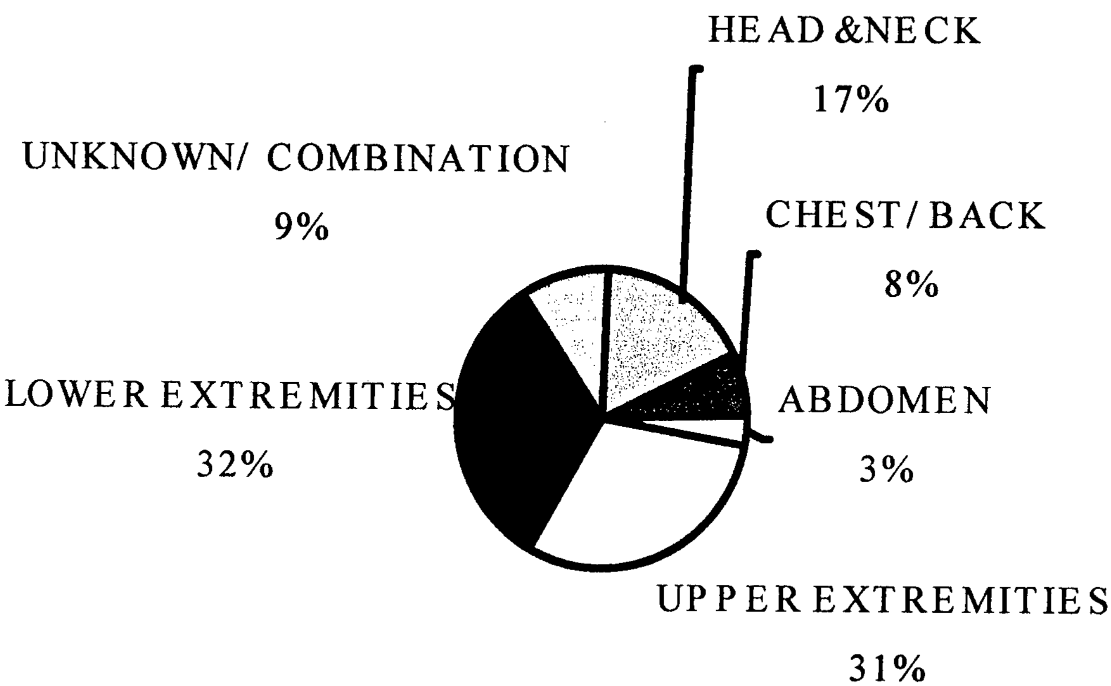
Fragment wounds to legs in night mission prior to TF Ranger raid. Still combat capable at time of TF Ranger.

Casualties from 7 October Mortar Attack

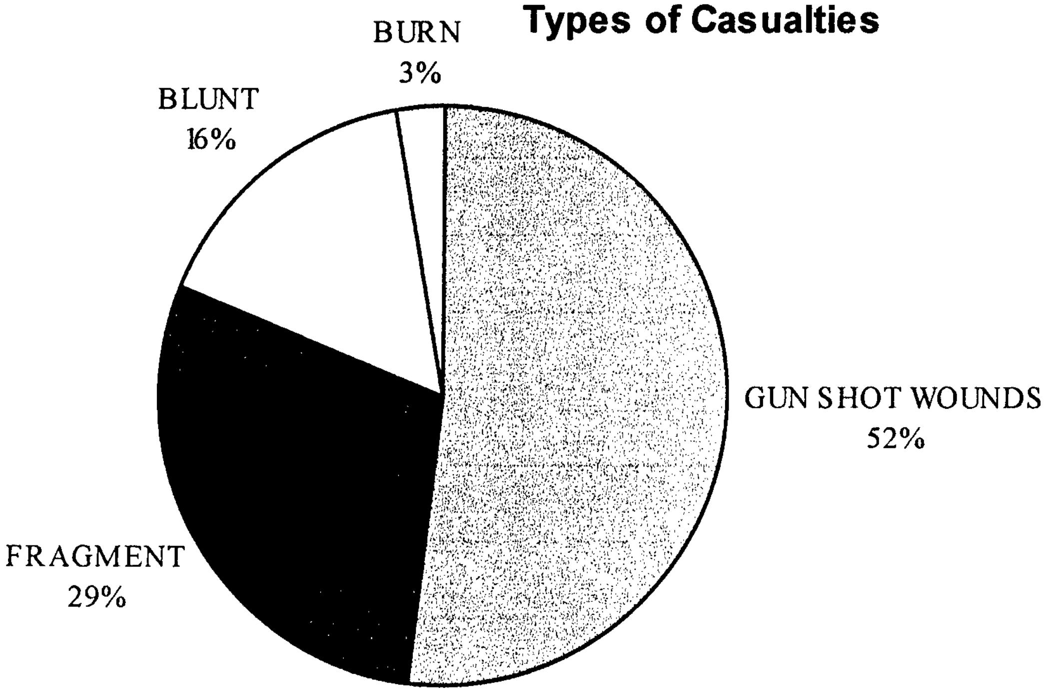
1. Fx R femur, frag wounds L lower leg
2. Shrapnel to back and hand
3. Frag wound L hand
4. Shrapnel L ear
5. Frag wound R knee
6. Frag wound R leg
7. Frag back and left hand
8. Frag wounds to head and chest
9. Shrapnel R leg and left side of back
10. R ext artery lac, R colon lac, massive transfusion
11. Frag R sternocleidomstoid
12. Combat stress

	GSW	FRAGMENT	BLUNT	BURN
HEAD/NECK	7	5	6	
CHEST/BACK	4	2	2	
ABDOMEN	1	2		
UPPER EXTREMETIES	19	11	2	1
LOWER EXTREMETIES	19	10	4	1
UNKNOWN/COMBINATION	5	1	3	1

Mogadishu Raid Casualties
Anatomic Wound Distribution



Mogadishu Raid Casualties
Wounding Mechanism Distribution



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KA Report: Proposed AMALs for the LPD-17

Appendix G

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Knowledge Acquisition Session Report

KA Session ID: MTG980217 **KA Session Date:** Feb. 17, 1998
Session Topic: Proposed AMALs for LPD-17
Knowledge Engineers: Michael T. Gately, ScenPro, Inc.
Expert Name / Rank / Service : various
Expert Phone Number:
Command Location:
Session Location: phone & e-mail **Time:** various
Type of Session:
_____ Interview _____ Task Analysis ____ Scenario Analysis
_____ Concept Analysis _____ Observation _____ Structured Interview
__X___ Other: __**Investigation**___________________________________

Initial Session : __X__
Documentation: KA Session Report, AMALs Kits for the LPD-17

Objectives

General Topic Area: Identify the proposed AMALs for the LPD-17.

Session Objectives: Work with a logistics expert to determine the expected AMALs loadout for the upcoming LPD-17 large deck amphibious ship.

Report Summary

Worked with a variety of logistics experts to gather data about AMALs distribution and allocation among different ships – and to determine which AMALs will be assigned to the LPD-17.

NOTES

Attached are the notes associated with this effort.

2/17/98 9:35am
Buck Buchannan 757/523-8131

Told him I got AMALs data...want to know which AMALs packs he thought would be on the LPD-17

His answer was to first explain what I had gotten from the web site, which were the 10 verification files (by type command).

Then he told me which are used on the current LPD ships (Austin class) - found in the Surface verificatin file.

Core
- 800 - surface ship core

Supplementary
- 902 or 903 - XRay - depending upon particular ship
- 912 or 913 - Lab - depending upon particular ship
- 925 - Basic Antidote Locker
- 927 - first aid kit
- 944 - Individual HM Kit (HM = Hospital Corpsman)
- 955 - bds - Battle Dressing Stations
- 964 - Portable Medical Locker

He also told me what one of the fields in the AMAL spreadsheet was:
cog - category of goods

Tried to call Master Chief Raney - but ended up talking with Chief Carnes. I asked him some questions about he column headings in the AMALs files. He couldn't help me, but he gave me the phone number of Joe Deane - who did help.

Joe Deane gave me the definitions of all the fields in the AMALs data:

COG	Category of Goods
AMAL	Automated Maintenance and Logistics
NEW_FSC	New item flag
NSN	National Stock Number
NOMEN	Nomenclature/Name
QUANTITY	Number of Units
UI	Unit (ex. Box, Each, Bottle)
UPRICE	Unit Price
UW	Unit Weight - pounds
UC	Unit Cube - volume in cubic feet
SL	Shelf Life
AAC	Acquisition Advice Code (open purchase, depot)
SC	sub code (equipment, durable, consumable, refrig, etc)
TIN	theraputic index (mostly found when NSN start with 6505)

He also explained that this was all the data there were.

He faxed me 11 pages showing which AMALs packs/kits were placed on which ships.

He told me that I should be using the LPH ship instead of the LPD.

Core
- 800 - surface ship core

Supplementary
- 802 - ?
- 803 - audio
- 806 - surgical
- 906 - xray
- 915 - lab
- 918 - ?
- 919 - flykit?
- 925 - Basic Antidote Locker
- 927 - first aid kit
- 937 - BMET Afloat?
- 944 - Individual HM Emergency Response Kit (HM = Hospital Corpsman)
- 955 - Battle Dressing Stations
- 964 - Portable Medical Locker

He told me that I would have to create a new field showing the true quantity of a supply if I needed that in my calculations.

Joe Deane

Can he tell me what the values for COG and SC (sub code) are, they will allow us to tell the difference between equipment, supply, etc.

Who do I speak with about the NBC supplies - and the fact that they were taken out of the AMALs data.

```
200,DENTAL TREATMENT ROOM (DTR) WITH PERIO AND PREVENTIVE CAPABI ,1DENTAL,
201,SURGICAL AND ENDODONTIC MATERIAL REQUIRED FOR EACH SHIP      ,1DENTAL,
202,DENTAL X-RAY                                                 ,1DENTAL,
208,DENTAL CHAIR (SEPARATE EXPOSURE ROOM)                        ,1DENTAL,
209,BASIC DENTAL EMERGENCY KIT FOR INDEPENDENT CORPSMEN          ,1ARS, CG,
DD, DDG, FFG, LST, LSD 36-40, MCM, MHC, SPECWARCOM, SPECWARCOM PC, SUBMARINE
CORE,
210,BASIC DENTAL EMERGENCY KIT FOR MILITARY SEALIFT COMMAND      ,1MSC,
211,PANOGRAPHIC X-RAY                                            ,1DENTAL,
213,SHIPBOARD DENTAL ALLOWANCE LIST AUGMENT                      ,1DENTAL,
220,PROSTHETIC CAPABILITY                                        ,1DENTAL,
221,PROSTHETIC CAPABILITY FOR LHD                                ,1DENTAL,
223,TYPE III LABORATORY                                          ,1DENTAL,
250,ORAL SURGICAL AUGMENTATION                                   ,1DENTAL,
255,CV- CVN AUGMENTATION FOR ANESTHESIA OR STERILIZATION         ,1DENTAL,
260,P-25-NMCB AIR ECHELON DENTAL                                 ,1MOBILE
CONSTRUCTION BN,
305,P-25 NMCB AIR DETACHMENT (EQUIPMENT)                         ,1MOBILE
CONSTRUCTION BN,
306,P-25 NMCB AIR DETACHMENT (CONSUMABLES)                       ,1MOBILE
CONSTRUCTION BN,
307,P-25 NMCB AIR ECHELON (EQUIPMENT)                            ,1MOBILE
CONSTRUCTION BN,
308,P-25 NMCB AIR ECHELON (CONSUMABLES)                          ,1MOBILE
CONSTRUCTION BN,
359,P-26 CIVIC ACTION TEAM- SEABEE                               ,1MOBILE
CONSTRUCTION BN,
362,P-29 NAVAL CONSTRUCTION REGIMENT                             ,1MOBILE
CONSTRUCTION BN,
368,P-1-A AMPHIB CONSTRUCTION BATTALION                          ,1MOBILE
CONSTRUCTION BN,
374,P-35 UNDERWATER CONSTRUCTION TEAM                            ,1MOBILE
CONSTRUCTION BN,
393,P-31 NAVAL CONSTRUCTION FORCE SUPPORT UNIT                   ,1MOBILE
CONSTRUCTION BN,
406,P-5 CONSTRUCTION BATTALION MAINTENANCE UNIT- LARGE           ,1MOBILE
CONSTRUCTION BN,
618,FLEET MARINE FORCE (FMF) LABORATORY EQUIPMENT                ,1FMF,
619,FLEET MARINE FORCE (FMF) LABORATORY CONSUMABLES              ,1FMF,
627,FLEET MARINE FORCE (FMF) X-RAY EQUIPMENT                     ,1FMF,
629,FLEET MARINE FORCE (FMF) PHARMACY EQUIPMENT                  ,1FMF,
630,FLEET MARINE FORCE (FMF) PHARMACY CONSUMABLES                ,1FMF,
631,FLEET MARINE FORCE (FMF) SHOCK SURGICAL TEAM/TRIAGE EQUIPMEN ,1FMF,
632,FLEET MARINE FORCE (FMF) SHOCK SURGICAL TEAM/TRIAGE CONSUMAB ,1FMF,
633,FLEET MARINE FORCE (FMF) ACUTE CARE WARD EQUIPMENT           ,1FMF,
634,FLEET MARINE FORCE (FMF) ACUTE CARE WARD CONSUMABLES         ,1FMF,
635,FLEET MARINE FORCE (FMF) AID STATION EQUIPMENT               ,1FMF,
636,FLEET MARINE FORCE (FMF) AID STATION CONSUMABLES             ,1FMF,
637,FLEET MARINE FORCE (FMF) PREVENTIVE MEDICINE EQUIPMENT       ,1FMF,
638,FLEET MARINE FORCE (FMF) PREVENTIVE MEDICINE CONSUMABLES     ,1FMF,
639,FLEET MARINE FORCE (FMF) OPERATING ROOM EQUIPMENT            ,1FMF,
640,FLEET MARINE FORCE (FMF) OPERATING ROOM CONSUMABLES          ,1FMF,
649,FLEET MARINE FORCE (FMF) X-RAY CONSUMABLES                   ,1FMF,
662,FLEET MARINE FORCE (FMF) FIELD DENTAL OPERATORY              ,1FMF,
684,FLEET MARINE FORCE MEDICAL LOGISTICS MISSION/GEOGRAPHIC      ,1FMF,
685,FLEET MARINE FORCE MEDICAL LOGISTICS MISSION/GEOGRAPHIC      ,1FMF,
686,FLEET MARINE FORCE MEDICAL LOGISTICS MISSION/GEOGRAPHIC      ,1FMF,
687,FLEET MARINE FORCE MEDICAL LOGISTICS MISSION/GEOGRAPHIC      ,1FMF,
688,FLEET MARINE FORCE MEDICAL LOGISTICS MISSION/GEOGRAPHIC      ,1FMF,
691,FMF MEDICAL LOGISTICS EQUIPMENT TEST & REPAIR EQUIPMENT      ,1FMF,
692,FMF MEDICAL LOGISTICS EQUIPMENT TEST & REPAIR CONSUMABLES    ,1FMF,
701,IDC CORE AMALS                                               ,1MHC,
702,IDC CORE AMALS                                               ,1MCM,
```

703,MSC (CORE ALLOWANCE; LEVEL I) WITH NURSE ,1MSC,
705,MSC (CORE ALLOWANCE; LEVEL II) WITHOUT NURSE OR DOCTOR ,1MSC,
721,MSC (CORE ALLOWANCE LEVEL III) CREW- IDC OR MEDICAL OFFICER ,1MSC,
803,AUDIO AMAL ,1LCC, MCS,
875,AGSS-555 ,1AGSS-555,
901,X-RAY LEVEL 1- PORTABLE ,1AGF, AOE,
LPD, LSD 41,
903,LEVEL 2 X-RAY ,1AS, LCC,
904,LEVEL 2 X-RAY- FIXED & PORTABLE ,1MCS,
905,LEVEL 3 X-RAY ,1CVN/CV,
908,LEVEL 3 X-RAY ,1LHA, LHD,
910,MILITARY SEALIFT COMMAND (LEVEL ONE LAB) ,1MSC,
918,MEDICAL OFFICER RESUSCITATION KIT (MORK) ,1AGF, AOE,
LCC, LHA, LHD, LPD, LSD 41, MCS,
919,MEDICAL OFFICER FLY-AWAY KIT ,1,
920,DIVING MEDICAL OFFICER EMERGENCY KIT (SURFACE) ,1ARS,
924,IDC EMERGENCY RESPONSE KIT (SURFACE FORCE) ,1MHC, ARS,
FFG, LST, CG, DD, DDG, LSD 36-40, MCM, SPECWARCOM, SPECWARCOM PC,
925,BASIC ANTIDOTE LOCKER ,1AFDM
SUBMARINE, AGF, AOE, ARS, AS, CG, CVN/CV, DD, DDG, FFG, LCC, LHA, LHD, LPD,
LSD 36-40, LSD 41, LST, MCM, MCS, MHC, SPECWARCOM, SUBMARINE CORE, SPECWARCOM
PC,
926,IDC EMERGENCY RESPONSE KIT (SUBMARINE) ,1SUBMARINE
CORE, AGSS-555
927,FIRST AID BOX ,1AGF, AFDM
SUBMARINE, AOE, ARS, AS, CG, CVN/CV, DD, DDG, FFG, LCC, LHA, LHD, LPD, LSD
36-40, LSD 41, LST, MCM, MCS, MHC, SPECWARCOM, SPECWARCOM PC, SUBMARINE CORE,
937,BMET AFLOAT ,1CVN/CV,
LCC, LHA, LHD,
938,OPTICIAN ALLOWANCE FOR CV- CVN ,1CVN/CV,
939,RECOMPRESSION CHAMBER ,1AS, ARS,
942,WOMAN AT SEA - MILITARY SEALIFT COMMAND ,1MSC,
944,JUNIOR HOSPITAL CORPSMAN - ALL SURFACE ,1AGF, AOE,
ARS, CG, DD, DDG, FFG, LCC, LHA, LHD, LPD, LSD 36-40, LSD 41, LST, MCM, MCS,
955,BATTLE DRESSING STATION (SURFACE)- EXCEPT AFOM- MHC ,1AGF, AOE,
ARS, AS, CG, CV/CVN, DD, DDG, FFG, LCC, LHA, LHD, LPD, LSD 36-40, LSD 41,
LST, MCM, MCS,
964,PORTABLE MEDICAL LOCKER (SURFACE) - ALL SURFACE ,1AGF, AFDM
SUBMARINE, AOE, ARS, AS, CG, CV/CVN, DD, DDG, FFG, LCC, LHA, LHD, LPD, LSD
36-40, LSD 41, LST, MOBILE CONSTRUCTION BN, MCM, MCS, MHC,
965,ARD- ARDM- AFDB- AFDM ,1AFDM
SUBMARINE,
970,SPECWAR MEDICAL OXYGEN KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU, SPECWARCOM
SBU, SPECWARCOM MK V MST,
971,SPECWAR MEDICAL OFFICER KIT
,1SPECWARCOM, SPECWARCOM SDVT, SPECWARCOM NSWG, SPECWARCOM CSBR,
972,SPECWAR HOSPITAL CORPSMAN SICK CALL KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU, SPECWARCOM
SBU, SPECWARCOM MK V MST,
973,PATROL COASTAL KIT
,1SPECWARCOM, SPECWARCOM PC,
974,SPECWAR SMALL CRAFT FIRST AID KIT
,1SPECWARCOM, SPECWARCOM SBU, SPECWARCOM MK V MST,
975,SPECWAR PLATOON RESUPPLY KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU, SPECWARCOM
SBU, SPECWARCOM MK V MST,
976,SPECWAR IDC SICK CALL KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU, SPECWARCOM
SBU,
977,SPECWAR TACTICAL SUPPORT KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU, SPECWARCOM
SBU, SPECWARCOM MK V MST,

978,SPECWAR COMBAT TRAUMA KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU, SPECWARCOM SBU, SPECWARCOM MK V MST,
979,SPECWAR DIVING MEDICAL KIT
,1SPECWARCOM, SPECWARCOM ST, SPECWARCOM SDVT, SPECWARCOM NSWU,
7001,IDC SUPPLEMENTAL AMAL ,1ARS, CG, DD, DDG, FFG, LSD 36-40, LST,
7002,IDC CORE AMAL ,1ARS, CG, DD, DDG, FFG, LSD 36-40, LST,
7003,IDC LEVEL ONE LABORATORY SUPPLEMENTAL ,1ARS, CG, DD, DDG, FFG, LSD 36-40, LST,
7004,IDC LEVEL ONE LABORATORY CORE ,1ARS, CG, DD, DDG, FFG, LSD 36-40, LST,
7005,IDC WOMAN AT SEA ,1ARS, CG, DD, DDG, FFG, LSD 36-40, LST,
7006,SUBMARINE TENDER CORE AMAL ,1AS,
7007,SUBMARINE TENDER SUPPLEMENTAL AMAL ,1AS,
7008,SUBMARINE FORCE CORE AMAL LEVEL 1 LABORATORY FOR SSBN/SSN ,1SUBMARINE CORE, AFDM SUBMARINE,
7009,SUBMARINE FORCE SUPPLEMENTAL LEVEL ONE LABORATORY FOR SSBN/S ,1SUBMARINE CORE, AFDM SUBMARINE,
7010,SUBMARINE FORCE CORE AMAL FOR SSBN/SSN ,1SUBMARINE CORE,
7011,SUBMARINE FORCE SUPPLEMENTAL AMAL FOR SSBN/SSN ,1SUBMARINE CORE,
7012,SUBMARINE TENDER WOMAN AT SEA AMAL ,1AS,
7013,SUBMARINE TENDER CORE LEVEL 3 LABORATORY ,1AS,
7014,SUBMARINE TENDER SUPPLEMENTAL LEVEL 3 LABORATORY ,1AS,
7015,GMO/PA CORE AMAL ,1AGF, AOE, LCC, LPD, LSD 41, MCS,
7016,GMO/PA SUPPLEMENTAL AMAL ,1AGF, AOE, LCC, LPD, LSD 41, MCS,
7017,GMO/PA WOMAN AT SEA AMAL ,1AGF, AOE, LCC, LPD, LSD 41, MCS,
7018,GMO/PA LEVEL TWO LABORATORY CORE AMAL ,1AGF, AOE, LCC, LPD, LSD 41,
7019,GMO/PA LEVEL TWO LABORATORY SUPPLEMENTAL AMALS ,1AGF, AOE, LCC, LPD, LSD 41,
7020,LABORATORY LEVEL THREE SURFACE CORE AMAL ,1MCS,
7021,LABORATORY LEVEL THREE SURFACE SUPPLEMENTAL AMAL ,1MCS,
7022,MCM LEVEL ONE LABORATORY ,1MCM,
7023,MHC LEVEL ONE LABORATORY ,1MHC,
7024,CV/CVN CORE AMAL ,1CV/CVN
7025,CV/CVN SUPPLEMENTAL AMAL ,1CV/CVN
7026,CV/CVN LABORATORY CORE AMAL ,1CV/CVN
7027,CV/CVN LABORATORY SUPPLEMENTAL AMAL ,1CV/CVN
7028,CV/CVN WOMAN AT SEA AMAL ,1CV/CVN
7029,LHA/LHD LEVEL THREE LAB CORE ,1LHA, LHD,
7030,LHA/LHD LEVEL THREE LAB SUPPLEMENTAL ,1LHA, LHD,
7031,LHD BLOOD BANK SUPPLEMENTAL AMMAL ,1LHD,
7032,LHA/LHD MEDICAL/SURGICAL CORE ,1LHA, LHD,
7033,LHA/LHD MEDICAL/SURGICAL SUPPLEMENTAL ,1LHA, LHD,
7034,LHA/LHD WOMEN AT SEA ,1LHA, LHD,
7100,TAH PHARMACY ,1TAH,
7200,TAH LABORATORY ,1TAH,
7210,TAH BLOOD BANK ,1TAH,
7220,TAH REAGENTS ,1TAH,
7300,TAH RADIOLOGY ,1TAH,
7400,TAH CASUALTY RECEIVING/PREOP ,1TAH,
7410,TAH CAST ROOM/ORTHOPEDICS ,1TAH,
7500,TAH CENTRAL SUPPLY ROOM ,1TAH,
7510,TAH ANESTHESIA ,1TAH,
7600,TAH OPERATING ROOM BASIC ,1TAH,

```
7610,TAH GENERAL/VASCULAR/THORACIC                                    ,1TAH,
7620,TAH UROLOGY                                                      ,1TAH,
7630,TAH ORTHOPEDIC                                                   ,1TAH,
7640,TAH MAXILLOFACIAL                                                ,1TAH,
7650,TAH EAR/NOSE/THROAT                                              ,1TAH,
7660,TAH OPHTHALMOLOGY                                                ,1TAH,
7670,TAH NEUROSURGERY                                                 ,1TAH,
7680,TAH GYNECOLOGY                                                   ,1TAH,
7700,TAH SICKCALL                                                     ,1TAH,
7710,TAH MEDEVAC                                                      ,1TAH,
7810,TAH LIMITED CARE                                                 ,1TAH,
7820,TAH INTENSIVE CARE                                               ,1TAH,
7830,TAH POST ANESTHESIA CARE                                         ,1TAH,
7840,TAH NURSING SERVICE                                              ,1TAH,
7890,TAH GYN NURSING                                                  ,1TAH,
7900,TAH PHYSICAL THERAPY                                             ,1TAH,
7910,TAH PREVENTIVE MEDICINE                                          ,1TAH,
7920,TAH BIOMEDICAL REPAIR                                            ,1TAH,
7930,TAH HEMODIALYSIS                                                 ,1TAH,
7940,TAH MEDICAL SUPPLY                                               ,1TAH,
7950,TAH MEDICAL PHOTOGRAPHY                                          ,1TAH,
7960,TAH FORMS AND PUBLICATIONS                                       ,1TAH,
7970,TAH EDUCATION AND TRAINING                                       ,1TAH,
7980,TAH CARDIOPULMONARY RESUSCITATION                                ,1TAH,
8000,TAH EYE/LENS CLINIC                                              ,1TAH,
8100,TAH DENTAL                                                       ,1TAH,
8110,TAH PROSTHETICS                                                  ,1TAH,
8120,TAH DECONTAMINATION                                              ,1TAH,
8200,TAH HUMANITARIAN                                                 ,1TAH,
8300,TAH MAT/CHILD                                                    ,1TAH,
```

KA Report: Mortality Rate Data and Data Structures

Appendix H

OF

Casualty Handling Simulation Using the Scenario-based Engineering Process

Office of Naval Research
Contract Number N00014-97-C-0317
Navy Small Business Innovation Research Program

ScenPro, Inc.

101 West Renner Road, Suite 130
Richardson, Texas 75082
972-437-5001

Approved for public release; SBIR report, distribution unlimited

Data Representation Report

Effort ID: MTG980202 **Effort Date:** Feb. 2, 1998
Effort Topic: Determination of the way to represent Survivability Curves data in code
Knowledge Engineers: Michael T. Gately, ScenPro, Inc.
Initial Session : __X__
Documentation: Data Representation Report

Objectives

General Topic Area: Data Representation

Session Objectives: Data Representation of survivability curves data in software

Report Summary

The attached report shows how to interpret and represent the survivability curves in software.

Report Details

We received a (large) document from Dr. Hesh Ansari. Without going into gory details, the 348 injury codes (patient codes) have been clumped into 29 groups. Each group has a set of numbers representing the survivability of the casualty at different points in his/her treatment. It seams as though there are three sets of numbers we may be able to use (out of six).

The first is a chart showing the initial triage category for casualties in the group. As an example, for casualties in Group 4 - Serious injuries to the liver, spleen, or crushed pelvis - 60% are immediate, 20% delayed, 0% minimal, and 20% expectant.

The second chart shows what percent of casualties return to duty from different places in the medical treatment roadmap. Listed are return to duty percentages from the Battalion aid station, the admit side of an Eschelon 2 facility, the evac side of an Eschelon 2 facility, and the evac side of an Eschelon 3 facility. Ad an example, for casualties in Group 4 there are 0% return to duty from any of these locations (i.e. all patients go at least to Eschelon 4 care).

The third chart - and the one we are most interested in - is the mortality rate/time-to-death chart. It has 4 lines: the first representing the survivability of a casualty who gets no care, the second for casualties who receive self/buddy aid, the third for arrival at Eschelon 2, and the fourth for patients leaving Eschelon 2 (evac).

For each line there are 8 numbers:

Name	Example for Group 4 (Esch 2 Arr)
Mortality Rate	30%
Time to Death 0-3hrs	25%
Time to Death 4-6hrs	5%

Time to Death 7-12hrs	5%
Time to Death 13-24hrs	5%
Time to Death 2-3days	5%
Time to Death >4days	55%
Time to Death unknown	0%

The way we plan to use this data is:
Each casualty gets a new variable called something like tTimeToDeath. When a casualty arrives at our facility we choose a random number between 0 and 1. If the number is greater than the listed Mortality Rate (.30 in this example), we set tTimeToDeath to infinity (or some other very large number). If the random number is less than or equal to the mortality rate then we draw a second random number. We use this number to figure out how much time the casualty will live. Using the above example, if the second random number is .31 then we sum the time-to-death probabilities until we reach this number ... in this case .35 > .31 giving us 7-12 hours of life. If we interpolate, we see that the casualty will die after 8.2 hours at the Eschelon 2 facility. So...we set tTimeToDeath to 8.2.

Each time the casualty is involved in an event we check the time that casualty has been in the facility with tTimeToDeath. If time ever exceeds tTimeToDeath then we declare the casualty dead and move him/her to the morgue.

So, what we need to do is...

1. add tTimeToDeath to the casualty data structure
2. add the data from the three tables to each TTT file
3. change the data structure that stores the TTT information to add fPercentInitialTriage[4], fPercentReturnToDuty[4], fPercentSurvivability[4], and fPercentTimeToDeath[4,7]
4. change the program that reads in the the TTT data to read in and store this data too
5. add code to compute tTimeToDeath whenever a casualty is created
6. add code to check the time the casualty has been in the facility with tTimeToDeath - then to kill the casualty if the time has been exceeded

You'll note that there is no plan to use the initial triage or return to duty percentages right now...but I figure we may as well add those values to the TTT file/data/code while we're changing them anyway.

There are many ways that we can add the data to the TTT files. The easiest would be to add these 40 values as the first line in the TTT. A more correct way would be to create a new set of lines (records) where the field SrcObj is a new value, such as ITC for initial triage category, then SrcSrv would be the Triage category, such as Immediate, and maybe the Units field could store the percent. I guess I'll let you pick - although you won't be stuck changing all the TTT files.

I think there is a pretty robust set of functions for random number generation in Visual C++. If you have any trouble with it call and I think we'll be able to work in out in short order. I'm wondering if we need to use the random number functions that are based on a user-defined seed - and if we need to have that seed be user settable.

The code to compute tTimeToDeath could look something like this. I'm assuming that this is hours...but it can be converted to any number.

```
  float fTotalProb = 0.0;
  float fRandNum, fRatio;
  //in next line, 2400 is a random guess, it really is infinity
  int   iTimeWidths[] = {0,4,7,13,25,96,2400};

  fRandNum = rand();
  //in next line, 6, not 7, since not using Unknown value
  for(int i=0;i<6;i++) {
    fTotalProb = fTotalProb + fPercentTimeToDeath[2,i];
    if (fRandNum <= fTotalProb)
    {
      fRatio = (fTotalProb - FRandNum) / fPercentTimeToDeath[2,i];
      tTimeToDeath = iTimeWidths[i] +
               ((iTimeWidths[i+1] - iTimeWidths[i]) * fRatio);
      bComputedTimeToDeath = true;
      break;
    }
  }
  if(!bComputedTimeToDeath)
  {
    bTimeToDeath = 2400; //<- 100 days
  }
```

Knowledge Acquisition Session Report

KA Session ID: MTG980223 **KA Session Date:** Feb. 20, 1998
Session Topic: Information needs to support casualty care
Knowledge Engineers: Michael T. Gately, ScenPro, Inc.
Expert Name / Rank / Service : Dr. Hesh Ansari
Expert Phone Number: (301) 619-7506
Command Location: Ft. Detrick, MD
Session Location: phone **Time:**.
Type of Session:
__X__ Interview _____ Task Analysis _____ Scenario Analysis
_____ Concept Analysis _____ Observation _____ Structured Interview
_____ Other: ______________________________

Initial Session : __X__
Documentation: KA Session Report, UHSUS Death Curves, Analysis Document

Objectives

General Topic Area: Survivability information gathering and modeling.

Session Objectives: Research how survivability modeling is done to identify what information is necessary to support survivability curves for BW casualty care.

Report Summary

Dr. Hesh Ansari is a Senior Staff Analyst at Ft. Detrick, Maryland. His area of expertise includes gathering and modeling casualty survival information. This patient survivability data can be used to model casualty care resource needs, including medical facilities and materiel and to assist with triage in a combat environment. The goal of this KA session was to research how survivability information is gathered, modeled, and stored – and how similar data can be applied to BW casualty care. The report that follows contains information gathered during an initial interview session.

Results

The Major Trauma Outcome Study (MTOS) is one of various databases related to patient survivability. MTOS data contains:

- Type of injury
- Average length of stay at each medical care level (ICU, hospital)
- % initial triage category
- % mobility of patient upon arrival (ambulatory vs. non-ambulatory)
- % return to duty
- % mortality rate

Data from the MTOS and other databases is used to generate survivability curves. Casualties follow a particular curve which relates chance of death to time since injury or last care (see attached). Weibull distribution applies in this situation. For example, a casualty has the following data:

Injury: serious trauma to the liver

Eschelon of care reached: II

Patient mortality rate: 30% (i.e. historically, 30% of patients who sustain this injury and have reached this eschelon of care will die)

Time until death:

Within 3 hours	25%
Between 3 and 6 hours	5%
Between 6 and 12 hours	5%
Between 12 and 24 hours	5%
Between 1 and3 days	5%
4 days or greater	55%

These data and their format, originally developed for conventional trauma injuries, are directly applicable to BW casualty care.